

THE SUPERLATIVE SONY.

THE NEW TC-766-2 HAS THE LOWEST WOW AND FLUTTER OF ANY DECK SONY EVER BUILT.



AN INCREDIBLE 0.018% (WRMS) AT 15 IPS, AND 0.04% (WRMS) AT 7½ IPS. Closed Loop Doud Capstan lope Drive System. One capstan extends from the motor shaff liself, eliminating intervening gears that can hamper speed accuracy. The other tape drive capstan connects through an extremely steady belt-drive inertial flywhet.

PHASE COMPENSATOR CIRCUIT. The goal of any recording is a "mirity" image" of the original signal. Sony's exclusive Phase Compensator Circuit comes closes to achieving this by rectifying phase distortion and producing sound quality virtually identical to the original source.

PROFESSIONAL STUDIO STANDARD VU METERS. Illuminated, calibrated and ultra-clear for the best monitoring possible, are identical in size, shape, color and sensitivity to those on professional consoles.

SYMPHASE RECORDING. Because of Sony's outstanding

Ferrite & Ferrite Heads, plus the remarkably precise fabrication and alignment of the head gap, recordings retain exact positioning of signal throughout the stereo field. The "location" of individual sounds won't wander. There's no annoying phase shift.

MORE PROFESSIONAL FATURES, The TC-766-2 has 4 incredibly durable Ferrite & Ferrite heads to 24 incredibly durable Ferrite & Ferrite heads to 24 incredibly durable ferrite & Ferrite heads to 24 incredibly and polyback. After the profile flashing standard supplied playback Fit ampillier, flashing standard supplied to the second and selected operated to glo-Control to 18 incredible flashing standard examplement. RM-30 flashifunction to let you move instantly to and from any made without stopping. Standard examplement. RM-30 flashifunction remote control unit with record mute and hinged head cover.

SONY

SUPERSCOPE.

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Consult the Yellow Pages for your nearest Superscope dealer. Finished in genuine walnut veneer over plywood side panels.



Hats off to IBM. Their single-element typing system did away with typewriter keys and started a new technology

The new Canon P10-D printing calculator starts another new technology. Their dualelement printing system does away with the standard printing head which required a separate disc for each column. The Canon has only two discs-one with digits and the other with symbols

The P10-D head weighs only 1/2 ounce compared to 31 ounces in a typical printing head. Its motor weighs only nine ounces-again much less than the heavier conventional motors required to drive larger heads. The Canon motor is smaller, lighter and more efficient because it moves less weight.

THE MOST FEFICIENT SYSTEM The printing head is controlled by an LSI

(large scale integrated circuit). As you press a key, a pulse is generated from this circuit and sent to the motor which does two things: 1) positions the two discs to print the numbers or symbols and 2) glides the numeric disc across the ten column width of the paper

Conventional printers print from metal discs through thick fabric ribbon onto paper. The Canon system prints directly on paper so each impression is sharp, clear and easy to read. The synthetic polymer disc is first inked by a special cartridge before it prints. Each ink cartridge is easily replaceable. The cartridge lasts for more than 15 rolls of paper at a cost of 17¢ per roll-far less than any other system.

PLAIN PAPER PLUS

Using standard paper tape is only one of several advantages that make the Canon a truly spectacular value. Here are some other exciting new features:

Dual Power Operate the Canon from either your AC outlet or its built-in rechargeable batteries. It's totally portable, yet it also makes a handsome desk calculator.

Dual Display Just flip a switch and the 10-digit large green fluorescent display can be used with or without the printer.

Space-Age Styling Compare the sleek appearance of the Canon with any other printer. It's small enough to fit in your briefcase and large enough to use as a space-saving desk unit. It measures only 134" x 414" x 81/2" weighs only 24 ounces and the paper tucks into the body of the unit-perfect for travel.

Buffered Keyboard If you enter your prob-

lems faster than the printer can print them out, don't worry. The unit's memory stores your keystrokes and prints them out in rapid

We have always looked at small printers as gimmicks-calculators that lack many important features. We were surprised with the Canon. It has features that far exceed most printers costing hundreds of dollars more.

The following is a list of those features: 10 digit capacity . full four-key memory . addition, subtraction, multiplication and division · percentage key · add-on and discount calculations e power and reciprocal calculations repeat calculations
 add-mode
 switch for full-floating or second and third fixed decimal positions . round off or round down switch . paper tape advance

There are other convenient features that make it perfect for people who spend hours at their calculators. There's a three-digit item counter that counts and prints out the number of entries while printing your total. The symbols on the right side of the tape tell you the nature of each entry. Even in its battery



The sleek appearance of the Canon P10-D makes it a handsome addition to any desk.



The direct-impression dual discs print cleaner and sharper on conventional paper tape.

CIRCLE 29 ON FREE INFORMATION CARD

operated position, you could print out more than half a roll of tape before the unit signals you that its batteries are low.

A NEW WAY TO BUY

JS&A offers you a new way to buy your 10-digit Canon P10-D. First we give you the opportunity to use one for 30 days. Carry it in your briefcase. Put it on your desk and see how handy it becomes and how little space it takes up. Check the paper tape and see how clear and easy-to-read it is. Bring it home and

let the whole family use it.

The full-featured \$89.95 Canon P10-D with its one-year parts and labor limited warranty is the greatest printer value ever offered by JS&A.

> Then, within 30 days, decide. If the Canon is not perfect for you, return it for a prompt and courteous refund. And if you do return it, not only will we still consider you one of our good customers, but we will also refund your \$2.50 postage, let you keep the paper tape, and thank you for giving us the opportunity of showing it to you. We couldn't be more positive about the quality and value of this incredible new product.

> JS&A is America's largest single source of space-age products. We have been in business for over a decade-further assurance that your modest investment is well protected. Canon is one of the world's largest manufacturers of cameras and precision quality instruments and is highly respected as a quality manufacturer of electronic products.

> The Canon costs only \$89.95 plus \$2.50 for postage and handling and includes a free roll of tape, one ink cartridge, rechargeable batteries and a power cord/charger. It's an incredible value thanks to its new technology. To order, send your check to the address below (Illinois residents add 5% sales tax) or credit card buyers may call our toll-free number.

Space-age technology has produced another major product breakthrough. Order your Canon P10-D at no obligation today.

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Model WTCPN. New convenience-leatures. Striking contemporary appearance. Completely new design. Now more than ever in a class by itself. Only Weller's advanced engineering could have improved on its own predecessor WTCPL Station, popular standard of the electronics industry.

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 new larger sponge for easier tip cleaning
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- Digital Techometer For Car Or Boat 2-digit LED display. Works with 2- or 4-cycle: 4-, 6- or 8-cylinder
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- All About Audio Oscillators Everything you ever wanted to know about this valuable piece of test equipment
- VTR Update Latest data on video tape recorders. Updates our February 1978 report
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- Delta modulation IC decodes and encodes

TELEVISION

- Jeck Darr's Service Clinic Troubleshooting horizontal sweep circuits.
- Service Questions Jack Darr solves technician problems. Wilson Frequency Counter

EQUIPMENT REPORTS

- 26 **Huntron Circuit Testar** 34 Kager Soldaring Pistol
- 119 Hickok CB Signal Ganarator

DEPARTMENTS

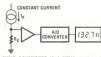
- 156 Advertising Index 14 **Advartising Salas Offices** 14 Editorial
- 16 Latters 123 Market Center
- New & Timely
- New Books **New Literature** 104 **Naw Products** 117 **Next Month** Readers' Service Cerd

113

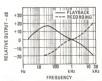
112

ON THE COVER

Ever see electronic clocks with digital readouts equipped with pendulums and tick-tock sound and chimes? We did! And here's a story on how they operate. It's an exploration into interesting circuitry you may not have seen before. The story starts on page 40.



OHMS CONVERTER IS A VITAL section of a digitel multimeter. It's only one of meny items to be considered when selecting e unit. For full selection data turn to page 63.



NEW RIAA EQUALIZATION CURVES. Note the rolloff in playback response in the low-frequency region. For full deteils turn to page 52.

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looking ahead

Hi-fi TV: Or perhaps I should say higher-fi TV. Anyway, it's good news for people who are always complaining about television sound. The American Telephone & Telegraph Company announced it has converted its entire intercity network-television relay system to an audio bandwidth of 15,000 kHz from the former AM-type bandwidth of 5,000 kHz. AT&T did this by diplexing the audio signal within the television signal, eliminating the former practice of separating television picture from audio and carrying the latter on a standard telephone line. The diplex operation, in addition to producing better sound, is expected to save television networks considerable money by eliminating the need for extra audio lines for TV sound.

Late this year, the AT&T says it will be able to offer stereo sound. Whether it does so or not presumably will depend upon the outcome of an FCC proceeding on stereo sound for TV. Interestingly, the Public Broadcasting System was one of the prime movers originally in working with the AT&T through industry committees on improved TV sound-but it won't share in the new development. PBS will be doing its networking via space satellite, which already provides full 15-kHz sound bandwidth.

CCD color camera: The first complete solid-state tubeless color camera to be demonstrated and announced for production has been developed by RCA Electro-Optics & Devices. The camera uses three tiny silicon charge-coupled devices smaller than a postage stamp with a matrix of 512 × 320 elements, for a total of 163,840 elements. RCA claims it provides sensitivity and other characteristics comparable to those of a highquality silicon vidicon camera. RCA said it would begin taking commercial orders for the camera in 1979. Initially, it will be offered as an Industrial-institutional closedcircuit camera, but eventually it will be offered as a consumer-product accessory for home video recorders. The camera demonstrated weighed 3.6 pounds and measured $4 \times 5 \times 6$ inches, about the same size as its accessory zoom lens. Many companies have been developing CCD cameras, including Bell Telephone Laboratories, Fairchild Camera, General Electric, Eastman Kodak, Nippon Electric, Matsushita (Panasonic) and Sony, and you can expect many more announcements in the near future.

Longer-play videodisc: There's furious competitionat least in the press releases-among the various videodisc systems before the first player hits the market, and this competition recently has centered on playing time. First, RCA announced it had doubled the playing time of its capacitance disc to two hours. Then Matsushita announced in Japan a mechanical disc system which will play for two hours. Now, Philips and MCA inc., sponsors of the optical system, have announced that they have developed a method to quadruple the playing time of their disc from the original 30 minutes to two hours. The original single-sided disc now has become a two-sided record. But to double the playing time per side, Philips and MCA use a principle which they call "variable angular velocity."

The original optical videodisc spun at a constant 1,800 rpm (for the American television system), storing a single TV frame per revolution. The new longer-play disc varies in playing time depending on the position of the stylus at any given time-so that the speed of the track being played is constant in relation to the laser-beam pickup. The disc, which plays from the inside out, starts at 1,800 RPM, but steadily decreases in speed until it's playing at about 600 RPM by the time the beam reaches the outside track at the end of the selection. Philips says its players wiii be able to accommodate both the variable-velocity discs and standard 1,800-RPM discs. The former will be known as continuous-play records and designed for such long programs as movies. Because the speed of turntable rotation isn't synchronous with the frame rate, these LP discs will lack some of the specific advantages of the optical system, such as freeze-frame, continually variable forwards and backwards motion, and precise location of a specific frame.

New video products: As the home TV set begins its metamorphosis from a single-purpose appliance to the multi-use home video center, new video products now are coming along rapidly. Projection TV, which in the past has generally been an area left to non-brandname assemblers, is now gaining adherents among major-brand manufacturers. Panasonic and Quasar, both subsidiaries of Matsushita, the world's largest TV maker, plan to market extremely bright and clear single-piece folding three-tube projection sets later this year. Mitsubishi will have a two-piece unit, strongly resembling Advent's projector, with shipments scheduled to start this spring. All three of these are expected to be quite high-priced. At the same time, a nationwide chain of retail stores specializing In projection TV is being formed, starting in California and moving east. It will offer the Projecto-Beam, which is like many other projectors using a single cathode-ray tube as a light source-except that it will be priced at \$750, in other words, about the same as a 25inch color console-and the company's officials think this price break wiii be what propels giant-screen TV into the biatime.

With the development of ultra-long-playing home video recorders (a six-hour cassette could come this year), the standard on-off VTR timer is no longer enough. Matsushita has developed an accessory programmer which will turn the recorder on and off and change channels, and is capable of being programmed for an entire week. Another such programmer, this one built into a television set, has been demonstrated by Sharp.

A few television sets, principally those made by GE. automatically adjust themselves to the vertical interval reference (VIR) used by broadcasters to keep color consistent. The GE circuit, which is discrete, uses 180 components and requires adjustment. Now Panasonic has announced development of VIR circuitry on an IC that is being offered to all TV set makers, and this could spread the idea of automatic VIR adjustment.

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CRT display terminals contribute to eve problems

Add "computer fatigue" to the list of eve complaints some observers feel are becoming more prevalent here and abroad as a result of the increased use of computer display terminals.

Dr. Jervi Sparks, a Dallas, TX, optometrist, has a number of patients who work at local electronics firms. Even while conceding that soreness and swelling and blurred vision can result from any close-work situation, on-site observations at the firms in question have led him to the conclusion that CRT terminals are the main culprits.

Dot-matrix printouts are particularly hard on the eyes; they require a continual focusing adjustment. A better choice of printout would be light-(illuminated) characters on a dark screen. Other factors contributing to eye problems are glare and the lack of contrast between normal room brightness and the brightness of the

Although these and similar observations are by no means conclusive and oninions vary among eye experts as to the validity of the diagnosis, some commonsense precautions can be taken to guard against potential hazards caused by CRT displays: look up from the work occasionally, take more breaks and blink-full blinking allows oxygen to reach the eyes, thus reducing swelling and soreness.

Cosmic rays believed to cause lightning zigzags

For some time, scientists have questioned the possible link between cosmic radiation and certain kinds of lightning behavior. At a recent meeting of the American Geophysical Union in San Francisco. Dr. James W. Follin of the Applied Physics Laboratory of Johns Hopkins University, presented a paper that bears out the conclusion that without cosmic rays there would be no lightning at all, since there is not enough electrical potential in a thundercloud to generate it.

Dr. Bernard Vonnegut, an authority on atmospheric electricity, and other scientists have theorized that the connection between cosmic radiation and lightning could be one of the ways in which sunspots affect the earth's weather. Cosmic rays are composed of highly charged particles, chiefly protons, that are released by the sun and travel at almost the speed of light. When there are many sunspots, the magnetic fields released from the sun's surface protect the earth from the majority of the cosmic rays; but the sun simultaneously increases its output of similar radiation at much lower energy levels.

Those cosmic rays with very high energy, when they strike the upper atmosphere,

create cascades of atomic fragments that are then released into our atmosphere as a "cosmic shower." This shower, when it connects with a thunderhead, knocks free electrons from nitrogen and oxygen atoms in the process known as ionization. The electrical charge already present in the cloud is sufficient to accelerate the released nitrogen and oxygen electrons to create a lightning stroke, known as a "step leader." This stroke then travels the path of least resistance to earth, following a series of steps, through segments of air ionized by secondary atomic ray atoms known as muons. Approximately 50 yards from the ground, an electrical discharge jumps up to join the leader stroke, creating a zigzag pattern. The circuit is complete and the return stroke follows the same zigzag path to the sky. This is the first lightning stroke one observes during a storm; the other strokes follow in such quick succession they appear as one.

Computer-operated disc-mastering system improves LP quality

A new disc-mastering system developed by CBS Records called DISComputer uses computer technology to improve both the sound and running time of LP records. The system cuts down on distortion and mistracking and contributes significantly to improving the signal-to-noise ratio. The records cut by the new system are also actually louder-by some 2-dB to 5-dB-than those cut by conventional methods.

The computer directs the lathe (with the



CBS DISCOMPUTER DISC-MASTERING SYS-TEM combines computer technology with conventional lathe to cut LP's with improved sound quality and longer playing levels.

stylus) to cut grooves according to prerecorded tape sounds and automatically adjusts the size of the groove to accompdate as much sound as possible. It also controls each groove's relationship to the adjacent grooves by providing the correct amount of space. And because more grooves can be fitted into the same space, the record side can be extended up to five minutes longer in some instances.

The system cost CBS more than \$500,000 to develop, and it is at present estimated at \$250,000 per unit. The DIS-Computer mastering systems are currently being used at CBS studios in New York, Nashville, and in some studios abroad.

Bell microwave-beam technique could increase satellite capacity

Researchers at Bell Laboratories have



BELL LABS' SCANNING/SPOT BEAM CON-CEPT uses about a dozen fixed beams and a narrow, focused microwave beam that would sweep across the U.S., thus increasing satellites' transmission capacity.

telecommunications that is expected to more than double the satellites' present transmission capacity. The scanning/spot beam technique uses narrow microwave beams that are broken into pulses lasting only minute fractions of a second to sweep the U.S. in much the same way as an electron beam sweeps a TV screen. Some fixed beams would be reserved for more densely populated urban areas.

The smaller beam size would raise the transmission capacity of each satellite from 15,000 to 50,000 phone calls. This substantial increase in the number of transmissions would be partly effected by transmission frequency reuse, at present feasible only in

continued on page 12

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NRI SCHOOLS

McGraw Hill Center for Continuing Education 3939 Wisconsin Avenue Washington, D.C. 20016 widely separated geographic areas. Raising the number of, frequencies would also mean there would be less interference from other microwave transmissions. For instance, at present both terrestrial and satellite communications use 4- and 5-glga-hertz channels; the scanning/spot beam satellite would transmit over 11- and 14-olgahertz channels.

Smaller (about 10 feet in diameter), less costly antennas could be used in urban areas, rather than in less developed regions as is present practice. The antennas could be installed on rooftops, thus permitting convenient access by businesses.

The concept, if developed, could go far in reducing the cost of multiple video conferencing and in increasing high-speed data transmission, while also lessening the cost of tile-lines and private communications networks extensively used by corporations.

Magnuson-Moss Warranty Act offers less consumer protection

A survey conducted for the FTC by the National Association of Service Managers (NASM) and sent to 83 manufacturers indicates that the 1975 Magnuson-Moss Warrary). Act has delivered less than was rearly act has delivered less than was protection. Originally intended to simplify matters for the consumer by outlining minimum warrarity standards and improving warranty protection. The Act has served only to confuse manufacturers (who are not support to the consumer support to the consum

The NASM survey showed that twohirds of the manufacturers who have over \$1 million in gross sales (producing such ltems as appliances, furnaces, automotive parts, stereos, Tv's, CB's, etc.) have witched from full to limited warranties. This means that consumers are now deprived of full warranty protection on their major purchases. Before the Act was passed, these companies tended to be the main providers of full warranties. Thirty-six of the 83 companies indicated they had of the 83 companies indicated they had of the 83 companies of the Magnuscon-Hoss as a direct result of the Magnuscon-Hoss

Announcing the result of the survey, NASM executive director Marvin Lurie said, "We now have solid evidence that the Act has reduced warranty coverage in major sectors of the consumer marketplace

... We hope that the data NASM has provided to the FTC will permit rapid correction of the situation."

rection of the situation."

Decoder system for traffic information broadcasts

When you are driving, especially long distances, it is a great convenience to be

able to receive periodic traffic information on your car radio. However, when you drive at high speed, the broadcast frequencies change and reception may not always be at optimum



SIEMENS DECODER SYSTEM uses three IC's to automatically select and tune to traffic information stations.

Slemens AG of Germany has designed a decoder system containing three different IC's that can automatically select and tune to a traffic information station. The ARI decoder system (presently being used in Germany) is based on two special broad-cast frequencies that are used by every raffic information station but cannot be traffic information station but cannot be tone that left you know, A. ST-ARIZ pilot tone that left you know, and a 125-kg frequency that is used for the actual broad-cast.

The two bipolar S280 and S281 IC's of the ARI decoder respond to the 574Hz and 125-Hz frequencies; [C S280 and IC S551 recognize the Iraffic service station by the pilot frequency; and IC S551 also controls the visual indicator, a green LED that tells you you have tuned in correctly, in operation, the system makes sure that the traffic announcements that interrupt regular programming are audible even if a cassette tape recorder is playing simultaneously. And even if the station volume has been lowered, the circuit assures the traffic announcement will come through loud and nouncement will come through loud and

The system also warns you when you leave the area so that you can tune into a new station. The decoder drives an automatic station-seeking device until the traf-

fic information program is restored. An optional iC (S552) is also available to identify different travel regions.

Microcomputers to improve U.S. Postal Service

Whenever the U.S. Postal Service must determine when, where and how to shift personnel to take care of special workload requirements, it must generally rely on online analyses, which generally arrive too late to be much use, or else keep a perpetual sharp eye out for potential bottlenecks

To alleviate this problem and, hopefully, maximize the efficiency of Postal Service operations, a pilot data-gathering system built by Applied Computer Research Company has been installed in a Sacramento, CA, facility. This monitoring system uses microprocessors to interface with conventional electromechanical equipment such as letter sorters and postage-cancelling machines. The microcomputers used in the system are Intel's SBC 80/04 and Zllog's Z-80. The Intel microcomputer board interfaces with the actual equipment, while the Z-80's handle system control. The Z-80, with its 4-MHz clock, hooks up to an on-site minicomputer and interfaces with the Postal Service Data System, a nationwide communications link, which contains all time and attendance records of the Postal System's entire workforce

It is hoped that the monitoring system will provide postal supervisors with enough information to be able to handle personnel shifts quickly and efficiently. While the Sacramento office is about the smallest postal facility that could expect to receive such a system, larger urban areas, such as Los Angeles and New York, that handle large amounts of mail could benefit from its installation.

FCC proposes eliminating Third Class Operator's license

The Federal Communications Commission's proposed reorganization of radiosion's proposed reorganization of radiotelephone operator illomating procedures advises eliminating the Third Class Operator's license. The National Radio Broadcasters Association supports this proposal, cilling the fact that in the past the Third Class Operator's exam was not really necessary for a broadcaster to function effectively. . . all that was needed was for the FCC to grant a one-year provisional permit.

The new rules would only require that technicians engaged in installing, repairing or servicing broadcast equipment be certified by the FCC—no exam would be needed. If any of the equipment does not fulfill the specifications required by the license, the technician must inform the licensee.



editorial

The Real Energy Crisis

Low-cost energy is the problem . . . not a shortage of energy itself.

Sure, at some point in time we will run out of oil, we will run out of natural gas, we will run out of coal. But there are plenty of other energy sources around. They include nuclear, solar, water power, wind, and who knows how many other sources that haven't been discovered yet.

The rising cost of fuel of all kinds is placing quite a hardship or most of us, but it does have a silver lining. It will result in the development of *practical* alternate supplies of energy; because it will pay, be profitable, to develop other sources.

You can buy solar cells today that have an efficiency of 18%, but we've got to get that up to 50%. We have solar hot-water heating systems today that work, but are expensive. What we need is a ruling requiring the installation of such a system in every new home. That would accomplish two aims—get a lot of energy-saving systems into use; and raise the volume of production so the cost of each system is reduced, making it more economical for people with older homes to add one.

Radio-Electronics is interested in our readers' ideas for alternate energy sources. Send me your thoughts. Include diagrams; photos if you have them. We'll publish the more interesting ones remember, if it's built around electronic circuitry, it has an edge.

My Steecher LARRY STECKLER Editor

Radio-Electronics.

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CIRCLE 36 ON FREE INFORMATION CARD

letters

AN OPEN LETTER TO THE PRESIDENT

Dear Mr. President:

We of the Maryland Electronics and Television Association feel it has become imperative at this time to denounce the foreign import practices allowed for too long by our government. We strongly urge that immediate steps be taken to cause a reversal in this trend of "overseas extortion."

Ion.

True, prices on television sets may be increased by strong governmental action against importing foreign sets, but it would be more costly for consumers to pay higher unemployment and welfare benefits to more unemployed, while ours decreases.

In recent years, Motorola sold its TV division to foreign interests, as did Magnavox. More and more, foreign countries' employment rates increase, while ours decreases.

We feel that if the government does nothing to combat this serious problem, organizations such as ours (and there are many) must take the initiative in refusing to sell or service foreign-made products. Of course, this would create a hardship on consumers who own such equipment, but we may be left with no alternative.

We appeal to you, Mr. President, to give this subject your earnest attention, and move to restore faith in our industry and system before we reach a point of no

We await your written response to this matter, which is of grave importance both to the Maryland Electronics and Television Association and the entire electronics industry.

EARL REDMAN, President META Board of Directors

CB TEST GEAR

I am very appreciative of the special feature "What You Need to Know About CB Test Gear" by Forest Belt in your November 1977 issue.

I was especially impressed with Mr. Belt's treatment of the test bench in the last section entitled "Test Systems," in which he gave a very well-defined method of setting up our own comprehensive test bench for servicing radio transceivers.

Please include more articles of this type in future issues as I am sure that I, along with the majority of other readers, will receive great benefit from them.

BYRON McCABE

Tucson, AZ

PARTS HARD TO FIND

I have noted recently some editorial comment in electronics magazines with respect to the trouble people have in construction projects due often to substituting other than specified parts. I would like to point out some problems in this regard.

continued on page 22



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John & Cunning ham

Special Projects Director Cleveland Institute of Electronics



y father always told me that there were certain advantages to putting all your eggs in one basket. "John," he said, "learn to do one important thing better than anyone else, and you'll always be in demand."

I believe he was right. Today is the age of specialization. And I

think that's a very good thing.

Consider doctors. You wouldn't expect your family doctor to perform open heart surgery or your dentist to set a broken bone, either. Would you?

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Specialists aren't for everyone.

I'll tell it to you straight. If you think electronics would make a nice hobby, check with other schools.

But if you think you have the cool—and want the training it takes—to make sure that a sound blackout during a prime time TV show will be corrected in seconds—then answer this ad. You'll probably find CIE has a course that's just right for you!

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Patterns shown on TV and oscilloscope screens are simulated.

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APRIL 197

1. Have you ever made up a list of exactly what is required and then gone out to the local dealers to try to get these items? Even If I limit my list to Radio Shack parts and catalog numbers. I can visit (and have visited) 10 New York stores without finding 75% of what I need. I now order by mall.

2. You have not provided any help in at least one area where it is badly neededcapacitors. I do not remember any article in your magazine (or any other) discussing what capacitors are sultable substitutions or what cannot be changed to any other type. I refer particularly to ceramic, silver mica, mica, Mylar, tantalum, etc.-also to

electrolytics. Why was each type emphasized and what is it really required for?

3. Resistors offer a somewhat simpler problem. So can you point out when you can substitute 5% resistors for 1% resistors, on wire-wound vs. carbon, etc.?

4. How about an update on what items now on the market really require heat-sink protection in soldering.

5. How about some practical specifications for handling static-sensitive AC-fieldsensitive solid-state items, MOS, etc.? B. M. SANFORD

White Plains, NY

DIGITAL CAR CLOCKS I read with great interest your October and November 1977 articles on "Digital Car Clocks," as I had just recently built James Electronics' Quartz Digital Auto Clock

It is working very well, but I still want to elther convert it or get a similar clock to count in decimal minutes (hundredths) instead of seconds for use in road rallye timing. This appears to require a special IC with a divide-by-100 in place of one divideby-60 and a 100-Hz frequency. Perhaps you may have discovered such an item during research for your article . . . any Ideas? A "split action" timing feature would also be of benefit.

In the October 1977 article you also referred to a Radio Shack WWV Converter Kit (No. 28-133 for \$5.95). I have inquired at several local Radio Shack outlets, and none of them knows about this kit. JOHN R. GINGRICH

Massillon OH

in answer to your first question, if you look in the latest Radio Shack catalog (1978, No. 289) on page 148 at the top, you'll find a super-duper "Quartz Computer Timepiece" for \$49.95. I have this identical Item, under the Casio brand name and have had it since it was introduced by Casio about five months ago.

it's terrifici The picture shown in the catalog is lust slightly smaller than actual size, in the stopwatch functions it reads decimal seconds, but not decimal minutes or hours. Real-time is retained when using the elapsed-time function. The AA battery for the display should last for 10 hours or so in regular use as a stopwatch, since the display is always on in that function. It's difficult to adapt this to external power except with the special AC adapter, because the lack is nonstandard (it uses a larger-than-standard center prong). If you could find a mating plug, you could drop the car 12 voits through a resistor (220 ohms, 1 watt should do it nicely, since the display draws about 50 mA), I don't know of any clock that counts minutes in hundredths, although it certainly could be done as you describe.

Regarding the Radio Shack No. 28-133 WWV Converter Kit, it has apparently been discontinued. It's not shown in their current cataioa.

FRED BLECHMAN



During an energy crisis, in desperation, we are apt to seek such far-out solutions as a "magnetic semiconductor" as described

by Andrew Fraser In the October 1977 issue Even If we should find such a material, Marc Scharf (same Issue) also wrote of a basic law of science that has never been violated. If the material is ever found, it will be impossible to improve it or any permanent magnets beyond a certain efficiency. By scientific law the screen must always use more power than the Iron block can generate.

It is hoped none of your readers waste their time pursuing John Ecklin's scheme as it is a complete flop unless we can find a 'magic semiconductor." Perpetual motion is Impossible even with all the many wonders of today's electronics. A. G. HOLT



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Two independent bus systems are provided for voltage and both sides of the board. In addition, the component side and the state of the board for a state of the board for a state of the board for a state of the board for a

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- INST MPG button is depressed, the dis-play indicates how many miles per galthe vehicle is attaining at each ment (up to 200 mpg). moment (up to 200 mpg).

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equipment reports

Wilson Electronics Model WFC-500-S. Model WFC-500-E Frequency Counters



CIRCLE 147 ON FREE INFORMATION CARD

THE WILSON ELECTRONICS CORPORATION (4288 South Polaris Avenue, Box 19000, Las Vegas, NV 89119) has introduced two versions of a new frequency counter, the models WFC-500-S and WFC-500-E. Both instruments are 6-digit types, with a dual range giving an 8digit resolution. The frequency range covered by the counters is from 10 Hz up to 500 MHz The model WFC-500-S (shown) has a rated accuracy of 0,0001%, and the model WFC. 500-E has an accuracy of 0.000002%, or 0.02 PPM. The model WFC-500-E uses a TCXO (temperature compensated crystal oscillator) clock

Both versions can be AC-powered, and have a selector switch that can operate on AC lines of 100, 110, 117, 200, 220 or 234 volts. They can also be powered by 12 volts DC, for mobile use, and both models come with AC and DC input cables, plus an input cable with clips. There are two BNC input jacks on the front panel. Input A is used for frequencies from 10 Hz up to 10 MHz, and it can be switched from a 1.0-megohm impedance to a 50-ohm input. The sensitivity is 25 mV in both switch positions. Input B is used for frequencies from 10 MHz up to 500 MHz, at 50 ohms, with a 100-mV sensitivity at about 20 MHz; this sensitivity reading goes to 25 mV at about 100 to 120 MHz, then gradually rises to about 100 mV at 500 MHz.

The 7-segment red LED readout is plainly visible. An overrange LED on the left-hand side of the readout shows when the input frequency is above the normal readout. Two LED's on the right-hand side show whether the reading is in kHz or MHz. For greater resolution, the initial reading can be displayed in MHz, with the decimal point placed three digits from the left. Incidentally, the counter has lead zero blanking that makes the display simpler to read. For example, if you read 45.75 MHz in the MHz position, all you see is "45.750." When you move this reading to the kHz position, the "45" scoots out of sight to

the left, and you then read "750,000" in kHz. The three digits on the right-hand side give you the reading in Hz!

In our bench test, we connected the counter to the color oscillator of a TV set during a network program. The reading was "3.580." Switching to kHz gave a reading of "575.545." The last digit rocked at times, first to "6" and then back, which is normal. We were glad to see that the network's atomic clock was still right on the button. We left the counter and went out for coffee; when we returned it was still reading exactly the same.

When you use the model WFC-500-E, which contains the TCXO, a standby LED on the panel lights up as soon as the unit is plugged in. This shows that the crystal oven is operating. The manufacturer recommends leaving the counter on for an hour for greater stability. We didn't warm it up nearly that long, but found it was quite stable within no more than 15 minutes, in the bench test described above and on other frequency stan-

The circuitry of the model WFC-500-S and WFC-500-E is thoroughly integrated. Standard IC's are used for flip-flops, counter, dividers, etc. The DC power supply is tightly regulated on both AC and DC inputs.

The layout of the front panel is neatly arranged. The input jacks are at the lower right-hand corner, with the selector switches in the middle. All controls are push-push types. with the switch positions plainly marked on the panel. The rear panel contains the 4-pin powerinput jack, a line fuse, and a BNC jack for access to the internal 1.0-MHz clock oscillator. The cabinet is made of sturdy metal and comes in two sections for easy access to the counter

Huntron Tracker Circuit Tester



CIRCLE 148 ON FREE INFORMATION CARD THE HUNTRON TRACKER IS A NEW VERSION OF an old circuit. This circuit is what some call an continued on page 32

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"angle tracer." This simple device displays a sharp angle on a scope pattern by feeding an AC voltage across the scope. Huntron Instruments, Inc., 15123 Pacific Highway North, Lynnwood, WA 88036, has really refined and perfected this device, which sells for a suggested retail price of \$695.00. State-of-the-art circuitry gives it much more versatility than

the original angle tracers. The Tracker has its own scope-a 2 × 3inch rectangular CRT. The scope controls are at the top of the front panel. Three pushbutton switches at the bottom of the front panel select HIGH, LOW or MEDIUM impedance for matching the circuitry to be tested. A fourth pushbutton is the ON-OFF switch. Also included are two test-lead jacks, and that's all. The test leads used are Huntron Micro-Probes. These probes have telescoping points and can be extended to almost 8 inches. The probe tips are quite sharp and are insulated almost to the very end for maximum safety in testing tightly packed circuit boards. You can check practically all parts from their side of PC boards; just push the sharp probe tips down into the holes

The Tracker uses a low AC voltage for test. This is both voltage- and current-limited by the circuitry. The tests will not damage any solid-state device; even MOSFET's can be safely checked, in-circuit. You can make quick tests on any kind of transistor, from bipolars to FET's, and even Darlingtons, which are hard

to check on many transistor testers.

In addition, the Tracker can check capacitors of any size, from .0025 uF to 4 uF on the

High-Z range, and from 2.0 µF to 5000 µF on the Low-Z range. The display for a good capacitor is a circle or an ellipse; if you see a closed loop, the capacitor is OK. The instrument also checks inductors such as power transformers, vertical output transformers, etc., for shorted windings, if you see a definite loop, the winding is OK. If the winding is shorted, you will not see a loop. For a shorted winding, the display will be a vertical line.

Diodes of all types are easy to check. Just touch the test leads to the diode. If you see an angle, the diode is good, You do not have to reverse the test leads as in other testing methods. Reversing the leads reverses the angle. If you see the angle, OK. The same thing applies to transistor junctions: If you see the angle, there you are.

The so-called good pattern for all junctions is a sharp angle with straight legs. The angle varies, from being quite acute in low-impedance circuits to quite wide in high-impedance circuits; but the key clues will be the same—the sharpness of the angle and the straightness of the legs of the trace. Leakage causes one or more of the legs to bend, and the corner will be rounded, and not sharp.

It is also possible to catch intermittent devices with the *Tracker*. The display flickers at the ends of the trace, or the whole pattern may be erratic and unstable. By monitoring the trace while heating or cooling the device, this test can be speeded up.

All the preceding tests can be made either in-circuit or out-of-circuit. Because you do have to reverse the test leads, the Tracker is ideal for speedy testing! You can use the special test probes to test all discrete transistors, diodes, resistors and capacitors on a

typical PC board in only a very short time. You can make accurate tests on TV mod-

You can make accurate tests on TV modules; all you need is one unit that's known to be good. Just check the same parts (test points, etc.) between the two units, and the defective part will soon be pinned down.

You can even test IC's in the same way. You do not have to know the pinout. If you have another IC of the same type, just take readings between the same pins of each IC and the pattern should be the same. These tests can also be made either in- or out-of-circuit, which can save a lot of time taking an IC out and putting it back in.

In some more complex circuits, such as control boards, memories, etc., there are often quite a few identical IC's on the board. You can use the Tracker to quickly compare key points between several of these IC's. If the same pattern is repeated on three of them, and an entirely different pattern shows up on the fourth, then the fourth IC should be suspected!

pected!

In all cases, the tests can be made with no power applied to the device, PC board, mod-luc, etc. The Tracker, in effect, feeds its own signal into the device and displays the results on the scope. In-circuit tests show slightly defined to the processor of shund the state of the scope. In-circuit tests show slightly defined to the state of the st

We connected the Tracker to a known continued on page 34





Our MRO replacement guide is required reading for people involved in maintenance, repair and operation of industrial electronic equipment.

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"I like how easy it is to read. Even in the bright sun, it doesn't wash out. And this DMM changed my thinking about LCDs in low light; if there's enough light to plug in the leads, there's enough light to read the display.

"With its LCD readout and low-power CMOS circuits, this meter draws less than 50mA, so its batteries last a long time. And its CMOS large-scale ICs assure me that it'll stay accurate over the long haul.

"I find this same quality built into all VIZ VOMs. Their WD-750A bench-type digital VOM has extra features like an analog reference meter which is conter-settable for nulling and peaking; a floating ground; a detachable power cord for complete AC isolation; low-power ohms; and an extra 20 Megohm resistance range. Its metal case provides great if shielding, and it has the same overload protection as the smaller WD-751A DMM. One service magazine I read just rated it excellent in performance — and I agree; in fact, in their test it even gave very accurate readings on DC having high inpile or pulses, where some DMMs are off by as much as 40%.

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EQUIPMENT REPORTS continued from page 32

"bad" throw-away TV module (which, of course, I couldn't bring myself to throw out!). This one had two identical IC's. A cross-check between the two showed distinctly different patterns between the same test points on the IC. So, we knew that one of the IC's was had

The instruction manual shows all the good and had traces that can be expected for any type of part-bipolars, FET's, diodes of all kinds, even SCR's and many four-layer de-

A handy supplementary brochure entitled the "Prober" comes with the Tracker. It contains quite a few specialized tests and hints on how to identify patterns, etc. This supplement is expected to be a continuing service: as new Tracker applications are discovered, they will be sent out to the users.

If it is properly used, the Tracker should be a useful instrument for all kinds of solid-state circuitry. The long Micro-Probe test leads make it very easy to get down into tight places, and the sharp probe tips also make it simple to test IC's from the top.

If you do repair your own modules, this instrument should be a big help by making fast cross-checking and comparison tests possible. Another good trick: the Tracker should make it a lot faster to service those jam-packed, noschematic little FM/AM radio receivers. You can check all transistors from the top in only a short time

Kager Model KL 3000 Auto-Feed Soldering Pistol



ALL MY WORKING LIFE I'VE KEPT A SHARP EYE out for time-saver tools, those small but useful items that will do only one thing but do it faster or easier.

I've just run into a new one: the Kager model KL 3000 One-Handed Soldering Pistol manufactured by Kager International Suite 710, 1180 South Beverly Dr., Los Angeles, CA 90035. The basic model retails for \$38. This gun is not a soldering gun, but a solder-feeding "pistol" that weighs less than half a pound, in the box!

It has a good-sized plastic pistol grip. The heating element is mounted in the upper part of the pistol. A guide tube feeds the solder directly onto the joint. The flow is controlled by a trigger that does not control the heat which is on continually. This tool should be useful for any kind of

PC-board work. It should also be a whizz at assembling all kinds of kits, especially those with many closely spaced joints, such as IC's, etc. Normally, you have to hold the board with one hand, hold the part in place with the other,

continued on page 119

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The new B&K-PRECISION Model 2810 may well be the highest resolution 3½-cligit DMM varieble. It is certainly the lowest cost DMM to provide 0.0Ω resolution. With ohms resolution ten times greater than most DMMs, the 2810 allows you to defect shorted windings in coils, transformers or motors.

You'll also be able to accurately check the low contact resistance of switches, relays, breaker points or connectors. Many poor solder connections or PC board imperfections can also be located.

The 2810 is a full-feature DMM providing selectable high-/low-power ohms, auto-zeroing and 100% overrange reading. Twenty-nine ranges provide maximum readings to 1500 volts DC. 2

amps, and 20 megohms. All ranges are fully overload protected. Typical DC accuracy is 0.5% with resolution to 100 µV. And unlike many electronic voltmeters, the 2810 is RFI shielded and can be accurately used in high R-F energy fields.

B&K-PRECISION also has a full complement of optional accessories for the 2810. Accessories include a carrying case, wire tilt stand, AC adapter/charger, high-voltage probe, direct/isolation probe, NiCad batteries and 10-

At \$119.95, the 2810 is a standout value in today's DMM jungle. Don't resist the temptation...contact your local distributor for immediate delivery.

PRECISION DYNASCAN CORPORATION

6460 West Cortland Avenue, Chicago, Illinois 60635 • 312/889-9087 In Canada: Atlas Electronics, Ontario

Automotive/Marine Digital Tachometer

Operate your car or boat at maximum efficiency by monitoring engine speed. This easy-to-build tach lets you keep a finger on your engine's pulse

MICHAEL H. KUHN

A CONSTANT AND ACCURATE CHECK ON engine RPM's is essential to the motor-boatsman for the following reasons:

- It is vital if the boat is to be operated at top efficiency and maximum fuel economy. By running a measured course at a constant engine speed, it is possible for the operator to determine fuel consumption per mile and per hour under average conditions.
- Engine speed can be a valuable navigation aid. Knowing the dis-

tance between two buoys or other points, an experienced boatsman can determine the engine speed needed to traverse the two points in a given time.

- Similarly, knowing the craft's most economical cruising speed, the pilot will be able to estimate the sailing time between two
- known points.

 4. Perhaps the most important reason for knowing the speed of a marine engine is the relationship

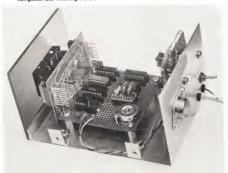
between RPM's and cruising range. Safety afloat demands that the pilot know how much fuel he must have on board to reach his destination or an intermediate fueling point with an adequate reserve.

An accurate engine-speed indicator is an important instrument for an aware automobile driver. For only by knowing engine RPM's can he obtain most efficient performance with minimum strain on the engine.

This digital tachometer overcomes the ambiguous swing of the analog-meter instrument. It can be used to measure the speed of 2 or 4-cycle automobile and marine engines having from two to six-teen cyclinders. It works on any 12 to 24 volt DC electrical system that has a negative ground. Its 7-segment display is wisible in darkness and shaded or dim sunlight and is not bright enough to affect the night-vision of a driver or pilot.

How it works

Digital and analog electronic tachometers operate by processing the voltects oppulses developed by the make-and-break of the breaker points of an internal combustion engine. These tachometers are basically frequency counters modified to indicate revolutions per minute. Before going further, let's look at the operation of a 4-cycle internal combustion engine. (1) The points open and close once per crank-shaft revolution per cylinder. (2) For all cylinders to fire (regardless of the number of cylinders) the crankshaft makes two revolutions. (3) The distributions of the distribution of the distribution



PERF-BOARD AND WIRE-WRAP was used exclusively to build the prototype. A total of three separate perf-boards was used.

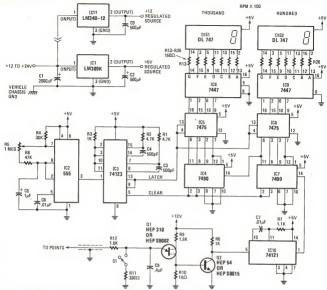


FIG. 1—TACHOMETER provides a direct readout of RPM × 100 on a 2-digit 7-segment LED display.

C1-200 µF, 50V, electrolytic
C2, C9-500 µF, 50V, electrolytic
C3, C4-500 µF, 50V, tantalum
C5-1 µF, 50V, electrolytic
C6, C701 µF, 50V, disc
C84 uF. 50V. disc
All resistors are 1/4 watt, 5%.
R1. R2—4700 ohms
111, 112 - 47 00 011110

R3, R8-1000 ohms R4-30,000 ohms

R5-1 megohm potentiometer

PARTS LIST

R6-47,000 ohms R7-1100 ohms R9-1500 ohms R10-15 ohms

R11-330 ohms R12-1800 ohms R13-R26-- 150 ohms

Q1-HEP310

Q2-HEP54

IC1-LM309K

IC2-555 IC3-74123

IC4, IC7-7490 IC5, IC8-7475 IC6, IC9-7447

IC10-74121 IC11-LI M340-12 S1-SPST toggle

DIS1, DIS2—DL747 common-anode 7segment LED display

utor makes one-half revolution during each revolution of the crankshaft. Since the distributor makes one revolu-

tion for every two revolutions of the crankshaft (No. 3 above) and since the crankshaft must make two revolutions for all cylinders to fire; the distributor points make-and-break-during each crankshaft revolution-only one-half as many times as the number of cylinders. Thus, in a 6cylinder engine, the points make-andbreak only three times for each engine revolution. Therefore, the tachometer

divides the number of pulses picked up from the distributor by half the number of cylinders.

Since a tachometer is calibrated in revolutions per minute, it would seem that we would count pulses for a full 60 seconds and then divide by half the number of cylinders to get a RPM reading. However, this is not the case. The tachometer electronics counts pulses for a second or fraction thereof and then multiplies that number by a factor that yields the number of revolutions per minute.

Consider an 8-cylinder engine running at 900 RPM. The breaker points operate 3600 times (900 \times 4) per minute. If we divide this by 60 (seconds), we arrive at 60 as the number of pulses developed ner second. Thus, at 900 RPM, the points generate 60-Hz pulses. Then, for the tachometer to display a "9" (for 900 RPM) we divide 9 by 60 and arrive at 0.15 second or 150 ms. This is the update time. If we want to display ten's, we divide 90 by 60 and arrive at a 1.5-second up-date time. Similarly, should we want The digital tachometer is shown in the schematic in Fig. 1 and block diagram in Fig. 2. Only two decades are used; indi-

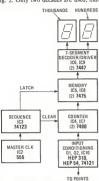


FIG. 2—BLOCK DIAGRAM of tachometer circuit. Master clock signals are provided by a 555-timer IC.

cating thousands and hundreds. Tens and units are not displayed as they would wander so much that the distraction would be greater than that of an erraiically bouncing needle of an analog instrument. Also, by displaying only thousands and hundreds, we can take advantage of a faster up-date time. For a 4cycle, 8-cylinder engine, we up-date at 150 ms. This provides a new reading approximately seven times a second.

To convert breaker-point openings and closings to engine RPM, the tachometer electronics performs all the math necessary for a direct read-out. The 555 timer, IC2, is the master clock. Its frequency must be adjusted, by R5, to suit the type of engine being monitored. Once set, this adjustment need not be touched unless the tachometer is switched to an engine of another type.

A dual retriggerable one-shot, IC3, provides the clear pulses for IC4 and IC7 and the latch pulses for IC5 and IC8. Transistors Q1 and Q2 and IC10 condition the input pulses from the distributor to produce a TTL-compatible signal. Switch S1 is used to adapt the tachometer to either standard or electronic ignition systems. Close the switch when the tach is used with electronic ignition.

The TTL devices and the displays



FRONT-PANEL OF TACHOMETER is made of red translucent plastic. Seven-segment LED display is mounted directly behind this.

operate from a regulated 5-volt DC line for from regulator IC1. The regulator input is 12 to 24 volts DC. Transistors Q1 and Q2 operate from a 12-volt source so 12-volt regulator IC11 should be installed if you plan to use the tach in a whiched that has an electrical system supplying more than 12 volts DC. By the same token, do not use IC11, if the tachometer is going in a vehicle with a 12-volt electrical system. Add a switch to by pass IC11 if the tach is to be used in both 12- and 24-volt vehicles.

Construction

I assembled the digital tachometer on perforated board using the wire-wap method. Sockets were used for the IC's, transistors and most other components. Be sure to use heat sinks on the regulator IC's. Use shielded cable or coax for the hook-up between the tachometer and breaker points.

Calibration and use

Calibrate the tachometer before inTO "POINTS"
CABLE
TO "CHASSIS"

GROUND

FIG. 3—CALIBRATION of the tachometer requires a low-level 60-Hz AC aignal. An inexpensive filament transformer will do nicely. stalling it in the vehicle. For this, you need a low-level 60-Hz signal—6.3 volts AC from a filament transformer (Fig. 3) will do nicely. Connect one lead to the shielded lead marked "to points" and

CALIBRATION TABLE

Engine Type (Stroke/ Cylinder)	Display Readout at 60 Hz (× 100)	
2/2 4/4	18	
2/3 4/6	12	
2/4 4/8	9	
2/6 4/12	6	
2/8 4/16	4*	
* Halfway between	* Halfway between 4 and 5	

connect the other lead to the shield. Connect the tach to a +12 to +24 volt DC source capable of delivering at least 1 ampere.

Refer to the calibration table and adjudy trimmer R5 until the read-out displays the number corresponding to the type of engine in your car or boat. For example, when properly calibrated, the tachometer reads "18" for a 4-cycle, 4cylinder or 2-cycle, 2-cyclinder engine.

Now, install the tachometer in your boat or car, hook up the cable and you are set to go. R-E

Unusual **Electronic** Clocks

Most of the clocks in earlier articles were **Displays Chimes**

FRED BLECHMAN, K6UGT

DIGITAL ELECTRONIC CLOCKS FOR THE home have been available both readymade and in kit form for several years More recently, digital clocks for cars have been appearing. Initially these clocks were mechanical, but electronic clocks have been making gains. The latest in sophisticated digital electronic timekeepers, however, are mantel clocks and wall clocks with simulated pendulums and sound. This article discusses three of the more recent designs in detail. An explanation of the circuitry of these timekeeners can teach you a lot about the uses of digital IC's.

table models. Here are details on full-featured wall and mantle models.

Comparison chart

The comparison chart shows the features of each of the clocks covered in this article. The do-it-yourself model is a miniature wall clock 4 inches high and 2 inches wide, using an LCD (Liquid Crystal Display) wrist watch.

Some of the terms used in the chart require some explanation. The "pendulums" are electronic and appear to swing as a result of the lighting of the LED's (Light-Emitting Diodes) in sequence. (Three different ways of doing this will be covered farther on in specific detail.) The "tick-tock" electronic sound simu-lates the sound of a typical mechanical pendulum clock. The "bongs" are belllike sounds, produced electronically, that count the hours-two for two o'clock three for three o'clock and so on. The "chimes" are musical notes arranged in the tune called "Westminster Chimes" that is used by the Big Ben clock in London. The alarms (on those clocks that

have them) are 24-hour repeating alarms, so that they can be turned off when they sound and turned back on the next day at the same time

Grandfather-style clocks

Strictly speaking, none of the clocks described are true "Grandfather" clocks. This is a term that generally describes large hall-type timepieces with chimes. bongs and pendulums. These clocks are all much smaller, and two are wall clocks. However, we call them Grandfather clocks because several have pendulums. sound and early-American-style cases

All the clocks have electronic digital displays and use digital circuitry except the Sankyo clock. It is a sort of hybrid instrument and is included because it plays the Westminster Chimes tune. All the clocks have wooden cases except for the Heath Electronic Clock Chimes unit. which fits into the case of the Heath Super-Clock. All operate from the 117-VAC power line, using the closely regulated 60-Hz frequency for accurate timekeeping, except for the "do-it-vourself" Micro-Regulator. It is battery-powered.

When you investigate how these clocks work you will see that no two are alike. Many different approaches have been taken to accomplish essentially the same goal-an accurate digital-display clock in a unique case with unusual conversationpiece features. Since each clock illustrates a different design approach, we'll cover each one in alphabetical order.

Amelect, Inc.

The model CL7402 Electronic Eve

wall clock has some unique pendulum and timekeeping display circuits; chimes, a tick-tock sound and bongs will soon be

Pendulums

The time is read from three concentric circles, with 60 LED's in each of the outer circles and 12 LED's in the inner circle simulating the tips of hour, minute and second hands. The lighted LED in the outer circle shows the seconds, the center circle shows the minutes and the inner circle shows the hours. The black front panel has white lines inscribed 30 degrees apart to represent five minutes, or one hour, as might appear on a conventional clock face. The pendulum at the bottom of the case consists of 10 LED's arranged in arc form. It's fascinating to



AMELECT, INC. CL7402 Grandfather wall-

watch the "seconds" march around the outer circle while the pendulum swings back and forth in exact synchronization-1 second in each direction.

The beautifully made wooden cabinet (available in natural walnut, mahogany, maple or cherry) is shaped like a tall wall clock (the top part is 91/2 inches square, and the total height is 191/4 inches); and there is a knick-knack shelf between the clock and pendulum sections. A diagonal version of this clock, model CL7401A, without the pendulum is available from Amelect, with or without a base

Figure 1 is the complete schematic of the model CL7402 wall clock. Although there are 16 IC's, 142 LED's (132 for the time indication, 10 for the pendulum) and many other parts, assembly is not

AMELECT, INC. CL7401A, diagonal version with/without base.

difficult, just time-consuming. The detailed manual takes you through the assembly step-by-step. Normal assembly precautions should be taken in building this kit and all the others described in this article: Use a small-tip soldering iron, check the solder connections with a magnifier to be sure there are no solder bridges and work slowly and carefully.

The instructions assume you are building this clock with the optional case. Unless you are a professional cabinetmaker, I recommend ordering the kit

with Amelect's preassembled cabinet. This clock circuitry uses many CMOS (Complimentary Metal-Oxide Semiconductor) 4001 Quad 2-input NOR gates. Just to refresh your memory, the positive logic action of a NOR gate can be described thus: The output is logic high only when all inputs are logic low; if any or all inputs are logic high, the output is logic low. If you can remember this as you read the circuit explanation, you'll be able to follow the operation of the rather



AMELECT CL-7402 pendulum circuit board, front view.

ingenious pendulum and hours-counter circuitry.

Circuit description

A transformer and full-wave bridge rectifier provide DC voltage. A 60-Hz supply is tapped off the transformer secondary and conditioned to a 60-Hz squarewave by AND gate IC1-b and IC2a. This conditioned 60-Hz supply is fed to the clock input of divide-by-6 counter IC12. Therefore, the carry output of IC12 is a 10-Hz squarewave (60 ÷ 6 = 10). This 10-Hz output is wired to the clock input of IC14-b, a flip-flop that divides by 2 at output Q, providing a 5-Hz supply for time-setting the minutes and hours counters.

The pendulum: The 10-Hz output from IC12 is also connected to divide-by-



42

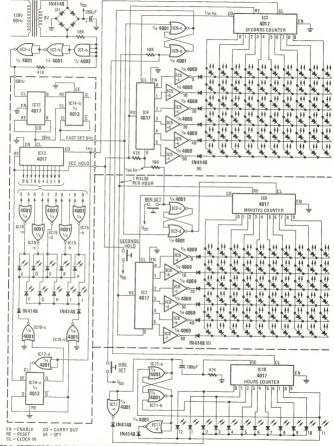


FIG. 1—SCHEMATIC DIAGRAM of the Amelec model CL7402 electronic wall clock. One hundred and thirty-two LED's are for time display and ten simulate the movement of a pendulum.

10 counter IC13. The 0-to-9 counting outputs of IC13 are wired directly to five 4001 2-input NOR gates so that they control 10 LED's one at a time. These LED's form the pendulum (see Fig. 2) that must swing back and forth. To describe this action, assume that IC13's output has just completed a 10-count cycle, so the 0 output is at a logic high. All the other outputs are at logic low, therefore, NOR gates IC15-b, IC15-c and IC15-d and IC16-a all have a logic-high output, thus keeping pendulum LED's B through Loff. However, since IC15-a has one logic-high input (from IC13, count 0), its output is at logic low, and this



FIG. 2—THE PENDULUM, simulated by twalva LED's, appears to pausa at the top of each swing.

enables LED's A and J to light, if they were receiving power from some other source. However, only LED A lights, and here's the reason why:

Referring to IC13, note that the carry output goes to IC12-d. This carry-output pin is at logic high for counts 0 to 4, and at logic low for counts 5 to 9. This polarity is inverted by IC12-d, which clocks flip-flop IC14-a. Because output Q is at logic low at this point, the output of IC16-c is at logic high, providing the current to light LED A. At the next count (1) of IC13, a tenth of a second later, LED B is enabled, then C at count 2. D at count 3 and E at count 4. On count 5, the carry output of IC13 goes to logic low and this is inverted to a positivegoing edge by IC12-d, thus clocking IC14-a. Instantly, Q goes to logic high and Q goes to logic low, which cuts off all the LED's that are connected to IC16-c and enables those that are connected to IC16-b. Therefore, at counts 5 through 9, LED's F. G. H. I and J light in that

Here's how to get the pendulum to swing back (or have the LED's light in reverse order). Counter IC13 is back to 0, but the IC16-b output remains at logic high. Why? Although the carry output of the counter has gone to logic high, IC12d has inverted this output to a negativegoing signal-and IC14-a responds only to positive-going signals. So the count progresses, lighting LED's J, L, H, G and F in order on counts 0 through 4. At count 5, however, flip-flop IC14-a sees a positive-going signal and changes state, with Q going to logic low and Q going to logic high. This then allows LED's E, D, C, B and A to light in that order on counts 5 through 9, and a complete backand-forth swing of the pendulum has been completed in 2 seconds. Note that conditions are now exactly as before, so the sequence repeats. Also, LED's A and J each stay lighted for counts 0 and 9, pausing realistically at the top of the swing.

Seconds and minutes counters: The 1-Hz output pulse of IC13 in the pendulum circuitry goes to divide-by-10 counter IC3. Each 0-to-9 output is at logic high for 1 second. These outputs are fed to 60 LED's that are arranged in a 6 × 10 matrix with 6 LED's wired to each of the 10 outputs. However, counter IC4, wired to divide-by-6, is used to ground each LED in the proper sequence. This takes the 0.1-Hz output of IC3 (one pulse every 10 seconds) to operate outputs 0 through 5 of IC4 for 10 seconds each. Whenever any output of IC4 is at logic high, the associated IC5 inverter grounds all 10 LED's in that line-but only the LED that is driven by IC3 for that specific second actually lights.

The output of IC4 in the seconds counter is one pulse every 60 seconds. This supply is fed through NOR gates IC2-e and IC2-d that are arranged as a flip-flor to the minutes counter, which the counts the minutes exactly the same way the seconds are counted.

Hours counter: The output of minutes counter IC7 is 1 pulse-per-hour and
is fed through filp-flop IC9-c and IC9-d
to hours counter IC10. In this case,
however, counter outputs 0 through 9 are
wired to four Nor gates (IC11) so that 12
LED's light up in sequence to indicate
the hours. Figure 3 shows how this is

HOUR	12	1	2	3	4	5	6	7	8	9	10	11
IC10 COUNT HI OUTPUT	0	1	0	1	2	3	4	5	6	7	8	9
IC11-a OUTPUT	L	L	Н	н	н	н	н	Н	Н	н	н	L
IC11-b OUTPUT	Н	н	L	L	L	L	L	L	L	L	L	н
IC11-c OUTPUT	н	н	L	L	L	L	L	L	L	L	L	н
IC11-d OUTPUT	L	L	н	н	н	н	н	н	н	н	н	L

FIG. 3—HOURS ARE INDICATED by LED's lighting sequentially. This is the logic truth table.

accomplished. At midnight or noon, on the count of 0 at IC10, the IC11-a output is at logic low, making the IC11-c output at logic high, disabling LED's 2 through 10. At the same time, the output of IC11b is at logic high (both inputs are at logic low), making the output of IC11-d low, thus enabling LED 12, which lights, driven by output 0 of IC10. On count 1, LED 1 lights, since the logic gates have not changed state. On count 2, the IC10 output drives IC11-b low at its output (since one input is now low), and this drives the IC11-a output high. The IC11d output goes high and the IC11-c output goes low. Simultaneously, a positivegoing pulse through a 100-pF capacitor resets IC10 to 0 and LED 2 lights. However, LED 12 does not light since the low at the IC11-b output makes the IC11-d output high.

Counter IC10 continues counting upward. At the third hour, the count is at
output 1 of IC10 and LED 3 lights. The
counter output is 2 at the next hour, but
reset does not occur at this time, since the
IC11-a output is already high and LED
dights. The count continues up through
output 9 which triggers gate IC11-a to a
low output, the IC11-b output to high,
the IC11-c output to high, thus enabling
LED 11 with a low output at IC11-d.
This procedure also sets all the logic for
hours 12 and 1 until reset by hour 2.

Time setting: A second-hold switch returns the second count to 0 and stops counting at pendulum IC13 by holding the reset at positive voltage. Releasing this switch starts the seconds counting from 0.

Separate switches set the minutes and hours. Both switches use Nor gates for switch debouncing. The "fast-set" 5-Hz signal from the pendulum (IC14-b) advances the LEPS around their circle at 5 minutes or 5 hours-per-second when the switch is pressed. Time-setting is thus easy and fast. Amelect, Inc., Box 367, Goodland. IN 47948.

Bullet

Almost all the features one could ask for have been included in this inexpensive Mini-Grandfather Clock. The optional clock case, designed for table or mantel use, is really a necessity for proper packaging of this relatively complex unit. Two large 41/2-inch × 61/2-inch PC boards are used, interconnected with 17 wires, a special four-position slide switch and a small speaker. The case comes pregrooved and predrilled; you simply screw it together. No glue is required. A back panel is used to mount the transformer, switch and speaker. You use one large ruby front lens, and the finished clock is 10 inches high, 8 inches wide and 5 inches

The 2-inch-long pendulum is composed of 21 LED's that are arranged in



FIG. 4—THE BULLET CLOCK has pendulum simulated by five strings of LED's as radii of the arc.

five "strings" (see Fig. 4). The display has four 0.5-inch-high digits, with a flashing colon and AM-PM indicators. The seconds are not shown but can be set. One PC board contains a conventional-design clock circuit that uses a direct-drive FCM 7010 clock calendar IC. No

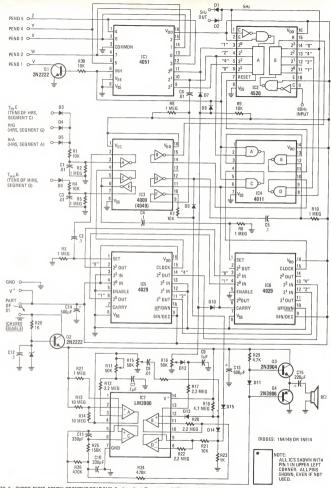


FIG. 5—THREE-DIGIT, SEVEN-SEGMENT READOUT displeys time. Twenty-one LED's form the "pendulum". Logic circuitry shown runs the clock, ticks the seconds and chimes the hours.

3

calendar and alarm functions are provided, however, because they would interfere with the "bong" circuit operation. Resistors are used to connect individual segment outputs of the FCM 7010 to the 4-digit display. The pendulum LED's also mount on this board. To assemble this board is tedious but not difficult. Various points on this board are then connected through wires (ribbon cable) to the loboard, that contains the pendulum, bong and tick-tock circuitry. No chimes are provided. However, at Heath Westimister Chimes is connected to one of these clocks, but this voids Heath's warranty!



BULLET MG-01, completely assembled. Time exposure shows all five pendulum positions.



BULLET MG-01 clock and logic boards side by side before interwiring. The clock board is on the left.

Logic circuitry

If you take time and effort to follow the logic-board circuitry shown in Fig. 5 closely, you will find that it illustrates many basic and inventive uses for IC's.

The logic circuitry shown in Fig. 5

performs three main functions:

 It "swings" the electronic pendulum:

It bongs the hours and counts;
 It tick-tock's the seconds.

All these functions are performed using the 60-Hz power line, using selected clock-display segment changes to set the bong count and enable function.

The pendulum: The pendulum "strings" shown in Fig. 4 are listed as V, W, X, Y and Z. The object of the pendulum circuitry is to light these strings in sequence so that the pendulum appears to swing back and forth every 2 seconds. The pendulum circuit (Fig. 5)

comprises IC1, IC2, and parts of IC3 and IC4. The 60-Hz power supply is received from the clock board, where it has been shaped and has had all negative portions removed. This 60-Hz power supply is fed to pin 9 of IC 2, a dual binary counter. Pin 9 is the input to counter B. Since enable input (pin 10) to this counter is held high, 60 counts-per-second are entered into B which counts up in BCD (Binary-Coded Decimal). When outputs 4 and 8 of this counter are both high, they trigger gate D (pins 8 and 9) of IC4, a quad 2-input NAND gate. Remember, for a NAND gate the output is low only when both inputs are high. So, the gate D output is low (pin 10). This low output is fed to inverter B (pin 14) of IC3, a hexinverting buffer. The inverter B output is therefore high (pin 15), which resets counter B of IC2 through pin 15. Thus, counter B resets on every twelfth pulse (4 + 8), making this a divide-by-12 counter. The 8 output (pin 14) of counter B goes low on every twelfth count. Since 60 counts-per-second are entering, then the counter B output at pin 14 is 60 ÷ 12, or 5 counts-per-second (5 Hz). Through, diodes D1 and D2, these high and low states set the clock-display-time hours and minutes, advancing 5 digits-per-secand.

The 5-Hz signal is also fed to clock input pin 1 of enabled counter A. It counts up and is reset through NAND gates A and B of IC4 when the count reaches 8 and 2, making this a divide-by-10 counter. Since 5 pulses-per-second enter counter A, it goes through a complete count of 10 in 2 seconds.

The BCD outputs of counter A go directly to ICI, a 1-of-8 decoder, which cycles through eight low outputs-0 through 7. Note that outputs 0 and 7 are connected together and to pendulum string W; outputs 1, 6 and X are also joined, as are outputs 2, 5 and Y and 3, 4, and Z. This makes the corresponding pendulum line low when either of the two pins in common goes low as long as inhibit pin 6 is also low. So, for counts 0 through 7, the pendulum LED strings each light for 0.2 seconds in the following sequence: W, X, Y, Z, Z, Y, X, W. But, what about string V? Since IC1 can only count to 8, the next two counts from IC2 counter A light up string V in this manner: On counts 8 and 9, the high on pin 6 (the binary 8 line) drives IC1* inhibit pin 6 high. This stops IC1 from counting. This same high signal simultaneously drives transistor Q1 into conduction, thus grounding pendulum string V. On IC2 count 0, IC1 inhibit pin 6 is released, Q1 is turned off and the sequence repeats, starting with string W again. Note that at each end of the pendulum swing (Z and V), the line stays low for two counts to simulate the pause effect of a real pendulum at the top of its swing.

Now that you're getting confidence in

your ability to follow all this logic stuff, let's dive into the bong circuit. Hold on tight and be ready for a rough ride.

Bong circuit: IC7 is a quad op-amp. with sections A. B. C and D. Section A is a squarewave oscillator whose tone is controlled by potentiometer R11. The squarewaye is fed to section B through volume control R15. Section B is an AC amplifier whose gain is controlled by a DC voltage supply from section D. Section C is used as a low-pass filter to round off the corners of the squarewave, providing a smoother sinewave-like tone. Transistors O3 and O4 amplify the output of section C to drive the speaker. Section D is a DC amplifier, used with potentiometer R16 and capacitor C9 to control the duration of the bong through section B. The four-position switch turns on power to this entire section, so the bong sound may be disabled. Zener diode Z1 and transistor O2 regulate the voltage. The bong sound is created by IC7 and its associated circuitry, but the digital circuitry controls when the bong should sound and how many times it should sound each hour. This is done primarily by IC5 and IC6, with the help of IC3, IC4 and IC2.

Up-down presettable counters IC5 and IC6 do the hours counting, along with IC3 inverters A, C and E, by sensing the time. The tens-of-hours segment C, and hours segments A and G of the clock display are connected through diodes D3, D4 and D5 to inverter A of IC3. When any of these segments are high (i.e., lighted), the inverter A input is high and its output is low. When all three monitored segments are low (only at 1:00 AM or 1:00 PM), the inverter output goes high. This charges C2, generating a short pulse to set input pin 1 of IC5. Since a positive voltage is permanently wired to the 2° input (pin 4), the counter clears and presets to 1 (2°) each time the set input receives a positive pulse at 1:00 AM or 1:00 PM. At 20 minutes past the hour, the tens-of-minutes G segment goes high, remaining that way until the beginning of the next hour when it goes low. The high tension at 20 minutes past the hour is detected by D6; changed to a pulse by C3, R4 and R5; double-inverted by inverters E and C; and applies as a positive pulse to clock input pin 15 of IC5. This advances IC5 by one count, since it is wired as an up-counter (pin 10 high). Therefore, at 20 minutes after the hour, an additional count is loaded into IC5. At 1:20, the total count held by IC5 is 2, at 2:20 the count is 3 and so on, until the count resets to 1 at 1:00 AM or 1:00 PM. When segment G of the tens-of-minutes digit goes low at the beginning of each hour, the inverter E output goes high, creating a positive pulse through C4 to set input pin 1 of IC6. Two things happen almost simultaneously: (1) IC6 is loaded with the count existing at the output pins of IC5; and (2) the IC6 carry output of IC6 (pin 7) goes high. Output IC6 is wired to continued on page 100



AM/FM Frequency Display

Part II. Update your hi-fi with this digital frequency and time display that you can add on or build into a modified AM/FM set. The construction is simple and inexpensive.

GARY McCLELLAN

IN THE JANUARY 1978 ISSUE, WE WENT step-by-step through the theory of operation and the basic wiring and construction of this time/frequency display that you can add to your AM/FM radio. In effect, it is a 12-hour clock that doubles as a radio frequency indicator.

Now that you have completed the modules, you have two choices in the final packaging. You can build the entire project inside the receiver as I did in a Sansui model 331 or build the display section as an add-on in an attractive cabinet that sits on too of the radio.

To build everything inside the radio takes a lot of courage. But, if you are an experienced electronics experimenter and constructor and don't mind tearing into a receiver, you should be successful. The advantages are that the finished modification looks very professional. The first thing you must do is to be sure you have room for all the parts. This includes a metal box or enclosure 7 inches high, 4 inches wide and 61/4 inches deep for the display and a box 31/4 inches high, 21/4 inches wide and 11/4 inch deep for the interface board. Then, there must be room for transformer T1 and space on the back panel for switches S1 and S2.

Figure 11 shows the additional parts and circuitry needed in the built-in version. The additional parts are mounted using point-to-point wirriag on a small piece of perforated board. There are several points of interest in Fig. 11. Display switching is done by taking voltages from the radio function selector switch which selects time, AM or FM. This switch must include a section that switches a positive supply voltage between the AM and FM sections.

The first step is to get the display working properly outside the receiver. Then you connect the switching and modify the receiver mechanically. The switching voltage for the time, AM and FM functions is not critical; it can range from +6 to +24 volts. Interface connections are shown in Fig. 12. This is covered in detail later in this article.

The second, and easier, method is to build the add-on version. This is because you don't have to make extensive mechanical modifications on the receiver. Also, if you have any doubts about your electronic skills, bay it safe and build this version. Refer to Fig. 13 for the related wiring on the display board and then to Fig. 12 for the interface connections. Mount the interface board in a type 772 LMB box, or similar enclosure, after punching holes for the RF input and output cables. Then build the display section into a type 463N LMB box or

other suitable cabinet.

Connecting to the receiver

Connecting the interface board to the receiver is the toughest part of the project but it's not too hard—you just have to know where to connect several wires. Figure 12 shows the local oscillator sections of a typical radio receiver. Dig out the schematic of your set and locate the local oscillators. In the less expensive sets you may find a single converter section—the same transistor is used for AM and FM. Interfacing is much the same.

Note that you will be working around the tuning capacitor and it is imperative that the interface board be mounted as

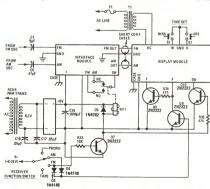


FIG. 11—HOW TIME/FREQUENCY DISPLAY is wired in built-in version. All external perts are mounted on a small piece of perforated circuit board. This arrangement was used in the Sansui receiver.



close as possible to the FM local oscillator The AM section is not critical-you can even use a short length of coax for the connections.

Back to the schematic, locate the emitter resistor of the FM local oscillator/ converter and tie C1 between it and the interface board. Keep the leads under 1 inch in length. Also, be sure to enclose the board in an aluminum utility box as mentioned earlier. Tie a short piece of ground braid from the interface board ground to the radio ground. Repeat this procedure with the AM section. Note that short leads are not as important here

(For those readers that are concerned about the possibility of detuning the RF circuits caused by the additions, we tried this project with the following results: A

+v -000 FM OSC OR TUNING CAS FM IN GNO AMIN = OSC COIL OOO RECEIVER

12-HOW THE INTERFACE BOARD IS CONNECTED to the receiver. You can use set's dial-lamp supply or separate filament transformer to feed the rectifier.

slight detuning effect was noticeable only on FM. It was so slight that realignment proved to be a waste of time. In addition to the Sansui model 331, we tried the time/frequency display on an Arvin receiver, a Radio Shack portable. a Delco AM/FM car radio and a Panasonic table model. All installations worked fine.)

While you are inside the radio, find a source of 8 volts or more to power the interface board. Usually you can get this voltage by removing the ground from the 6.3-volt AC dial lamp supply and attaching a bridge rectifier and filter capacitor as shown in Fig. 12. This source of power is desirable because it goes off and on

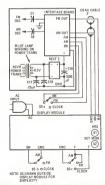


FIG. 13-AUXILIARY CIRCUITRY for the add-on version. Mode switch S3 is installed inside the display module box but is drawn outside for

with the receiver. If you prefer, substitute a 6.3-volt, 600 mA filament transformer. If you get hum on strong AM stations add capacitors C17 and C18. Route the output cables out of the back and attach a plug PL1 to match the 9-pin tube socket or connector (J1) on the back panel of the main module.

Let's try it out

If you used the built-in version, plug in the receiver. The clock colons will light and you will get a reading of 000. Press SET HRS and, after a delay of several seconds, the hours will advance. Do the same with SET MIN and adjust the display for the correct time. Your clock is now working, (Remember the delay whenever you set the clock. This is a built-in feature.)

Turn on the AM radio and you'll get readings such as 640, 1220, 1540 and so on. The last digit will always be 0 in this mode. You should now be able to look up a station, dial its frequency and hear it! Do the same with FM. Note that you get a smooth transition between odd numbers such as 97.3, 97.6 MHz, etc.

The add-on version works the same way, but you must manually change the switch (S3) to read time or radio frequencv. You can select the time mode without disturbing the radio-a bonus feature over the built-in version.

There are a few advantages this display has that haven't been mentioned. First, the clock section can be operated as an elapsed-time indicator. When you plug it in-after allowing 5 minutes for the filter capacitor to discharge-the entire clock is zeroed and will begin counting elapsed time in hours and minutes until the interval you are timing has ended. Also, the add-on display will run without the receiver and the receiver can operate without the display so the clock can be handy around the house. R-E

All About The S-100 Bus

The 100-line bus that is almost standard equipment in 8080 computer systems. Here we look at the bus and how those 100 lines are used.

WILLIAM BARDEN, JR.

ONE OF THE MOST BENEFICIAL EVENTS IN the microcomputer explosion was the establishment of the S-100 microcomputer bus by MITS, Inc. MITS defined the S-100 bus by the design of the Altair 8800 in 1975. Although they did not intend it as a standard, it soon became one as IMSAI, Polymorphic Systems, Processor Technology, and others brought out microcomputers compatible with the S-100 bus structure. In addition to many microcomputers that use the S-100 bus. there are dozens of manufacturers producing memory boards, I/O boards, speech synthesizers, and other hardware compatible with the S-100 bus structure. This article will explain the basis for the S-100 structure in terms of the microprocessor for which it was designed, the 8080A, discuss the signals of the bus, and describe basic interfacing to the bus.

Physical characteristics

The S-100 bus is a collection of 100 logic and power signals developed from the microprocessor signals. Some signals are logically identical to the signals from the 8080, while others are related, and still others are signals defined by MITS. Physically the bus is represented by a printed-circuit board called a motherboard with 100 parallel foil strips and several 100-pin connectors that are soldered to the foil of the PC board. The typical PC boards that plug into the connectors on the motherboard have 100pin edge connectors and are the approximate size shown in Fig. 1. A complete S-100 type microcomputer system could consist of the motherboard, power supplies, and a number of S-100 plug-in modules, such as a CPU (Central Processor Unit) module, memory modules, and I/O (Input/Output) modules.



FIG. 1—TYPICAL S-100 BOARD has 100 edge connectors; 50 on each aide of the board. These boards are intended to piug into the S-100 mother board.

8080 and the S-100

The 8080 microprocessor IC is the heart of most S-100 bus systems, although other microprocessors could be and are being used. Let's first describe the 8080 signals and then see how they relate to the S-100 bus. The pinout of the 8080 is shown in Fig. 2. Most signals are TTL compatible and most are active high

The 8080 requires three voltages, +5V, -5V, and +12V as indicated. In addition, timing within the 8080 is controlled by a two-phase non-overlapping clock represented by \$\emptyset{0}\$1 and \$\emptyset{0}\$2.

Data is transferred bidirectionally between the 8080 and external devices by the data bus, shown as D7 through DO. Data may be instruction data, memory reference data, or input/output data. The 8080 addresses external memory to get the 8 bits of data by means of 16 address lines A15 through A0. Since binary values from 000000000000000 through 1111111111111111 may be contained on the lines, 65,536 different memory locations can be addressed.

When the 8080 executes an instruction, it goes through a predefined instruction cycle controlled by the internal logic of 8080. In the course of the cycle, the 8080 first outputs the address of the current instruction on the address bus. It knows the current address from the content of an internal register called a program counter. External memory decodes the 16-bit address from the bus and also detects another 8080 signal, DBIN, that indicates that an input (to the CPU) operation is to take place. External memory gates the 8 bits of the selected memory location onto the data bus and the CPU strobes in the data some time later in the cycle. During this fetch cycle, the

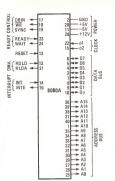


FIG. 2—THE 8080A MICROPROCESSOR IC has the pinout arrangement shown here. Most signals from the IC are TTL compatible.

first byte input represents the complete instruction if the instruction is the instruction is a one-byte instruction. If the instruction is a two- or three-byte instruction is a two- or of the fetch cycle picks up on the first byte of the instruction. By decoding this first byte (the operation code), the CPU knows whether or not to make none, one or two more memory reads to obtain the remainder of the instruction.

When the CPU has the complete instruction, the fetch cycle is completed and the execution cycle begins. There are a wide variety of instructions the CPU may execute, but they essentially involve internal functions, reading (again) from memory, writing to memory, reading from an I/O device, or writing to an I/O device.

Reading from memory is similar to the fetch cycle. The address bus holds the memory address of the 8 bits of data to be read and signal DBIN is enabled. If data is to be written to memory, the address bus still holds the memory address of the data to be read, but signal DBIN remains low, and at the proper time signal WR is brought low to strobe the data into external memory. When the CPU executes a read or write (I/O) instruction, the sequence is similar to a memory read or write. The address bus contains the I/O address on lines A7 through A0, as there are only 8 bits available for an I/O address in an I/O instruction.

If data is to be input to the CPU from an external I/O device, signal DBIN is once again high and if an output operation is taking place, DBIN is low and WR is low. How does the I/O device know whether the input or output is from memory or from itself, though? For example, the CPU could read data from

Description Date Bue Bit Symbol DITA Interrupt acknowledge MO Indicates a write to memory or output is about to occur STACK Indicates the address bus holds stack address Acknowledge for HALT instruction D3 HI TA Output device address on address bus; data bus will hold output Π4 OUT data when WR active D5 341 CPU in fetch cycle for first byte of Instruction IND Input device address on address bus; data bus will accept input data DE when DBIN active D7 MEMB Data bus will be used for memory read data

memory location 55 and immediately follow that instruction with an input from I/ O device 55! To differentiate between I/ O addresses and memory addresses, additional signals called status signals are used. There are eight status signals and they are output on the data bus during the beginning of each machine cycle during the time when signal SYNG is high. The status bits and what they represent are shown in Table 1.

The READY signal of the 8080 is an input signal that enables the 8080 to interface with slow memory or 1/O decives. If the memory evel time is not fast enough to allow the memory to respond with data for the CPU, for example, the memory logic may bring down signal READY to a logic ol level. This causes the CPU to insert an extra clock period in the instruction cycle for as long as READY is low. When in a "not ready" condition, the CPU responds with a WAIT signal that is output to external devices.

The RESET signal is an input that accomplishes what the name describes. It is used before program execution to reset the program counter to zero. Program execution then proceeds from memory location to zero, as previously described for the fetch operation.

The 8080 has the capability, as do most microprocessors, of temporarily suspending instruction execution for direct-memory-access, or DMA. DMA permits external memory to be accessed independently of the CPU for high-speed I/O that cannot afford the time required for the CPU to issue a simple byte at a time. When an external I/O device controller makes a HOLD request, the CPU responds with an HLDA (Hold Acknowledge), indicating that it has released the address and data buses to the external device. (This is important to avoid the conflict of use of the buses by both the CPU and the external device controller simultaneously.) Normal CPU operation resumes when the external device controller brings the HOLD signal to a logic 0 level.

The remaining two 8080 signals, INT and INTE, are associated with CPU interrupts. An interrupt is an external signal that forces the CPU to suspend program execution at the current instruc-

tion location and transfer control (or jump) to a predefined address that contains an interrupt program. An example of this might be a CPU dedicated to running a control program that is interrupted when a Teletype key is depressed. The external signal causing the interrupt is INT, which causes an interrupt entry entry if the control program has enabled the interrupt enable flip-flop. The state of the interrupt enable flip-flop is brought out on line INTE.

The above description outlines the 8080 signals necessary to interface external devices to the microprocessor. Now let's see what MITS did with the microprocessor against to construct a working microcomputer with a control panel, memory and I/O. What they did in the 8800 design defines the S-100 bus.

S-100 bus signals

Power signals: the +8V, +18V and -18V unregulated lines are provided on the S-100 bus. These voltages are regulated to +5 and other required voltages by on-board regulators for each S-100 module.

Data buss The 8080 data bus is buffered in the S-100 configuration to provide a greater driving capacity. In addition, the data bus is converted from a bidirectional bus to two unidirectional buses. Lines DO7 through D0g is the data bus coming out from an S-100 CPU while lines D17 through D1g is the data bus going into an S-100 CPU. The oupput lines are enabled by S-100 bus signals DO DBS that connects to tri-state buffers (see Fig. 3.)

Address bus: Lines A15 through AO of the 8080 are buffered in the S-100 bus system; the tri-state enable signal is ADDR DSBL (see Fig. 3).

The six command and control ouputs described for the 8080—SYNC, DBIN, WAIT, WR, HLDA and INTE—are logically unchanged, but buffered in the \$5.100 bus system. Their tri-state buffer enable signal is C/C DBS. The six signals are renamed PSYNC, PBIN, PWAIT, PWR, PHLDA and PINTE (see Fig. 4).

The eight status bits of the 8080 are latched into a status latch, as shown in Fig. 5. The status bits listed in Table 1 now become SINTA, SWO, SSTACK, SHLTA, SOUT, SM1, SINP and SMEMR. Status is disabled by signal STATUS DSBL. A memory write signal MWRITE is developed from SMEMR.

Four inputs to the 8080, READY, HOLD, INT and RESET are either buffered or latched from the S-100 bus signals PRDY/XRDY, PHOLD, PINT and PRESET.

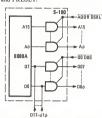


FIG. 3—IN THE 8-100 BUS, the data lines from the 8080 are buffered by tri-state buffers as shown in this diagram.

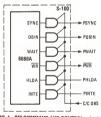


FIG. 4—SIX COMMAND AND CONTROL outputs are also buffered for the S-100 bus. These alguals and the buffering can be seen here.

The 91 and 92 clocks are developed in the S-100 CPU circuitry and routed to the system via S-100 bus outputs 91, 92 and CLOCK. The latter is 92 inverted. Signal POC, Power on Clear, is developed in the power supply logic and indicates when system power is on.

The above signals are S-100 bus signals intimately associated with the 8080, and together with unused pins cover about 80% of the S-100 lines. The remainder of the lines are for the most part associated with vectored interrupts and control panel functions in the microcomputer.

Signals VI0 through VI7 are eight vectored interrupt lines. The 8080 provides eight vectors or pointers to interrupt locations with proper external logic. Signals VI0 through V17 are S-100 system signals fed to an interrupt board that would implement these functions.

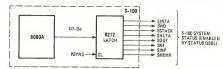


FIG. 5—EIGHT STATUS BITS of the 8080 are latched into a status latch as shown here. When desired status is disabled by signal STATUS DSBL.

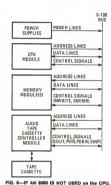
Control panel signals in an S-100 microcomputer system may be present on the S-100 motherhoard that does have a control panel or they may be strapped to the proper logic level. Some control panel signals may be simply deprived from switch settings, Signals PROT and UN-PROT would typically be derived from a switch on a front panel that controls alteration of data in memory. Signals PRE-SET or EXT CLR may be derived from a momentary switch for system reset and clear of external devices, Signals RUN and SS indicate that the system is running or that a single-step switch is being used to step through a program, respectively. Signal SSWI indicates that a data transfer from the control panel sense switches is to take place, for example, altering memory contents.

Although most manufacturers that make S-100 motherboards have made their boards consistent with the above signals, some incompatabilities de exist, especially in cases where undefined pins have been used to carry required new signals. Boards of this kind are not completely compatible with the S-100 bus and may not be used without some modification.

An S-100 system

Now that we've seen the 8080 signals and their relation to S-100 bus signals, let's look at a typical S-100 bus system. We'll assume that the system uses an 8080 CPU card that contains only the 8080 microprocessor and related logic. This will probably consist of buffering and an 8212 status latch. Many of the S-100 bus signals are generated on this board, such as A15 through A0, the status signals and clock signals. Alternatively, the CPU board might contain a Z-80 or even a 6800 microprocessor. However, if a different microprocessor is used it must generate compatible S-100 signals. In many cases, additional logic will have to be added to the CPU board to create S-100 signals. See Fig. 6 for a look at the kinds of signals that may have to be added

The memory boards in the system use the 16 address lines as inputs to select the memory location being accessed. If the board is an 8K (or 8192) byte board, 13 lines, A12 through A0, are used to select the specific memory location of the 8K while A15 through A13 are decoded to



8-100 signals.

select which of the 8K boards is being accessed. Signal MWRITE is used to select the read or write function for the memory IC's on the board, while SMEMR gates the data out to lines D17 through D19 on a memory read.

A typical I/O board in the system is an audio tape controller. The address of the controller is decoded from address lines A7 through A2. Address lines A1 and A0 are used to decode functions of the controller such as read and write. Data is output from the controller on lines D07 through DOØ when the controller address is selected on lines A7 through A2, when a write function is specified by A1 and A0 and when SOUT and PWR are logic l levels. Signal SOUT indicates "output address available" and PWR indicates "data available." Data is input from the controller from lines DI7 through DI0 by decoding signals PDBIN, SINP and A7 through A0. Signal PDBIN is the 8080 DBIN (input address available).

The above describes some of the rudiments of S-100 bus operation. Although the S-100 bus has lately taken its share of abuse, it does work, it's adaptable, it's fairly efficient, and most importantly it is one of the few standards in an otherwise chaotic hobby.

ON THE S-100 BUS

This chart is a partial listing of manufacturers of hobby computer products that fit (plug into) the 5-100 bus. To conserve space, we have not listed addresses or phone numbers here. A complete list of addresses and phone numbers is available FREE. Simply circle number 120 on the Readers Service Card Inside the rear cover of this

issue. If we've left anyone out of this directory we'd like to know about it. Send us data on any missing entries so we can include them in the future. This is the first in a continuing series of directories that will cover all aspects of hobby computers. Look for more directories covering other bus svatems later this year.

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Canada Systems	1		L_	L	_		_					_	Real Time Clock; AC Controller
Central Data	•	<u>_</u>	•	_	_			_					
CMC Marketing	•		•	L	•	•	<u> </u>		•			_	A/D Converter; D/A Converter
Computalker Consultants							_				•		
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Digital Group, The						•							AC Controller; DC Controller
Digital Research Group			•										
Electronic Control Technology	•		•										Extender; Prototyping
Equinox Div.			•										
Extensyn Corp.			•						•				
Godbout													Mother, Extender, Control, Terminator Board
Heuristics													
Imsal						•		•	•				
International Data Systems													Clock; Data Access; Frequency Counter; Mod- em; Clock; D/A Converter
I.O.R.													
Ithica Audio			•										Prototype; Blank
Micropolis	\top								•				
Micro Systems Development								•					
MITS													
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National Multiplex													System Controller
Peripheral Vision			1										
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Processor Technology	1	T		Т									
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TDL		1		_		T		•					System Controller
Thinker Toys	+	\vdash	1						\vdash				
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Xybek	+	+	-		+	+-	-	-	1	-	1	\vdash	

New RIAA Equalization For Records

The playback curve of your hi-fi phono system must be the converse of the equalization curve used by the record maker. New equalization curves promise better overall performance

FERRIARS NOT MANY HI-FI ELECTRONICS manufacturers (or even audiophiles) are aware that the Record Industry Association of America (RIAA) has, recently approved a brand-new recording and phyback equalization curve. Before you panic and start taking your preamplifier, amplifier or receiver back to the manufacturer for modification, let's review some basic facts regarding record equalization, both at the recording and at the playback ends.

Back in the late 1940's and early 1950's, when long-playing records were first invented, almost every record manufacturer used his own form of record equalization. There were practically as many standards as there were record companies. Manufacturers of preamplifiers (separate hi-fi components were the rule in those days) prided themselves on the number of equalization-switch positions they offered on their products' front panels. Some preamplifiers featured as many as 36 different playback curves, and you had to change the setting every time you played a record from a different company.

Why equalization?

You will understand how equalization works during the recording process by considering how a magnetic cutting head works. Normally, such cutting heads operate as constant-velocity devices; that is, given a flat-frequency response input to the cutting head, the cutting stylus moves with constant velocity regardless of the frequency. However, the lower the frequency.

LEN FELDMAN CONTRIBUTING HI-FI EDITOR

quency to be recorded, the farther the cutting stylus must move to maintain its constant-velocity characteristic, as shown in Fig. 1.

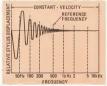


FIG. 1—CONSTANT-VELOCITY CUTTING HEAD requires greater stylus displacement for lower input frequencies.

In the case of a long-playing disc, allowing the cutting head to behave as a constant-velocity device all the way down to the lowest frequency would have meant that grooves would have had to be spaced quite far apart if those high-amplitude, low-frequency undulations were not to cut through from one groove to the nacted that the cutting the state of the

tic with a 500-Hz turnover frequency (the frequency at which stylus motion changes from constant velocity to constant amplitude).

In addition to permitting closer groove spacing by changing the cutting mode at the turnover frequency, recording companies also began to pre-emphasize high frequencies—but for quite another reason. In the high-frequency region, the cutting head again operates in the constant-velocity mode, which means that the amplitude of the wiggles in the groove becomes progressively smaller. At very high frequencies, the amplitude of the signal undulations may not be much



FIG. 2—CONSTANT AMPLITUDE/CONSTANT VELOCITY characteristic used in cutting records.

greater than the inherent surface noise irregularities in the vinyl disc itself. By boosting highs during the recording process, the recording company effectively spreads the distance between signals and noise, or, to put it simply, improves the high-frequency signal-to-noise ratio.

An idealized two-part recording equalization is shown in Fig. 3. Frequencies below 500 Hz are attenuated, while frequencies above 1 kHz (for example) are boosted. From this basic idea came the



FIG. 3—S/N RATIO at high frequencies is improved by introducing treble pre-emphasis to the constant emplitude/constant velocity characteristic.

many variations of equalization curves that were introduced in early preamplifiers.

RIAA standardization

In June, 1953, the disc recording industry, concerned with the variety of equalization curves required to properly play back recordings from different manufacturers, adopted a standard recording and playback curve that was approved in March, 1964, by both the RIAA and the NAB (National Association of Broadcasters). In a very short time, all discs manufactured worldwide were using these standard curves. The official playback curve used at that time is shown in Fig. 4. This characteristic can be obtained by using a circuit consisting of a parallel L/ R network having a 3180-µs time constant, a series R/C network having a 318μs time constant and a parallel R/C network having a 75-us time constant. "Zero" reference level is taken at 1000 Hz. An actual frequency response plot taken at the output of a precision phono preamplifier shows how closely the playback curve corresponds to the point-by-

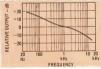


FIG. 4—OLD STANDARD RIAA plsyback equalization curvs has been in use for many years.



FIG. 5—ACTUAL PLAYBACK EQUALIZATION CURVE of old RIAA standard.

point plot shown in Fig. 4. This plot was stored on the scope face of a spectrum analyzer and is shown in Fig. 5.

In both Fig. 4 and Fig. 5, the frequencies are specified (and shown) only in the 30-Hz to 15,000-Hz range. At the time the RIAA curve was adopted, there were virtually no recordings that contained frequencies beyond those low and high extremes. Even if they did, the likelihood was that home equipment would not have faithfully reproduced such frequency extremes in any case.

However, consider the situation of a typical amplifier manufacturer of the time. Since the low-frequency time constant was set at 3180 µs, in theory at least, if a manufacturer's amplifier (or preamplifier) had a response below 30 Hz, the bass boost continued to rise, as shown by the extended curve in Fig. 6. If the manu-



FIG. 6—MANY EQUALIZATION CIRCUITS provide base boost below the low frequency limit of the old RIAA curvs.

facture did nothing to rolloff the bass response of his product, bas boost provided in the preamplifier-equalizer circuit would be around 20 dB at 20 Hz, 23 oB at 10 Hz and, if the amplifier response continued to be even lower (for instance, to 5 Hz) the bass boost would be around 26 dB at that ultra-low subsonic frequency.

Most early records did not contain frequencies below 30 Hz, and amplifiers and preamplifiers did not have uniform response much below 20 Hz either. Therefore, in most cases, there was a natural rolloff in response caused by the amplifier circuit itself rather than by any specific equalization circuitry built into the preamplifier section.

und preampriers section what has been happening in amplifier penamptier technology in the past of years. Today, it is not uncommon to find amplifiers, it is not uncommon to find amplifiers, and the penamptier technology in the past of find amplifiers, and the technology and the way down to 10 Hz at even lower. Some new so-called DC amplifiers can amplify signals as low as "O'Hetzt," or DCI Such amplifiers, when combined with preamplifiers whose low-end equalization rises at a 6-dB-pen cotave rate below the RIAA-specified 30-Hz point, can amplify subaudible tones at an increasing ratio.

Rumble

Consider what this extreme bass boost does to turntable rumble. In the early days, most turntables used 4-pole motors that were coupled to the turntable platter either via an idler wheel or via a belt. A 4-pole synchronous motor rotates at 1800 rpm. This translates to 30 revolutions-per-second, or a fundamental wibrational rate (based on the premise that the worst rumble occurs at a once-per-revolution rate of the motor shaft) of 30 Hz. This frequency is, of course, well within the audible range and there isn't much you can do about it.

Today, however, many turntables use motors that rotate at a slower speed. A fle-pole motor (commonly used in a popular line of turntables) has a 450-pole motor passed, which translates to a fundamental rotational vibration of only 7.5 Hz. If there is significant vibration transmitted from the motor to the cartridge via the pickup arm, that frequency will be need-lessly amplified by some 24 dB referenced to a 1000-Hz signal if the amplifier has flat response down to that low frequency.

Not surprisingly, many amplifier and preamplifier manufacturers have been aware of this problem for some time and have incorporated so-called subsonic cutoff filters that rolloff response beginning at some frequency at or below 20 Hz. While it is true that you cannot hear rumble that occurs at frequencies below 20 Hz, you have only to remove the front grill of one of your speakers while playing a silent groove of any record on your turntable with the volume turned up high to see what such low frequencies do to the woofer cone. You may find that it is wobbling wildly in and out at some subsonic rate that, although inaudible, places the speaker cone in its nonlinear operating range during much of the time that it is trying to reproduce the music that you do want to hear.

For these reasons, the RIAA has adopted a revised playback curve as well as a slightly revised recording curve. Both new curves are shown in Fig. 7. Note that

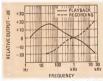


FIG. 7—NEW RIAA EQUALIZATION CURVES. Note the rolloff in pleyback response in the low frequency region.

the response peak for the bass section of the playback curve now occurs at 31.5 Hz and begins to rolloff below that frequency. The rolloff occurs by introducing a fourth R/C network with a 7950-us time constant to the three existing networks that make up the equalization circuit. The high end of the equalization curve is

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Just as television is only one part of the consumer field, these other fields of electronics are made up of many career areas. For example, there are computer electronics, microwave and satellite communications, cable television, even the broadcast systems that bring programs to home television sets.

As you may realize, career opportunities in these other areas of electronics are mostly for advanced technical personnel. To qualify for these higher level positions, you need college-level training in electronics. Of course, while it takes extra preparation to qualify for these career areas, the rewards are greater both in the interesting nature of the work and in higher pay. Furthermore, there is a growing demand for personnel in these areas.

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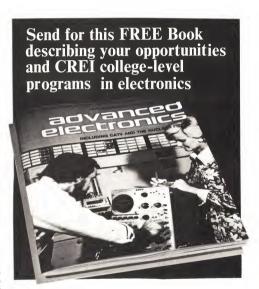
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Relative level (dB referenced to 1 kHz)								
Frequency*	"Old" RIAA	"New" RIAA	Net Difference					
100	+13.11	+ 12.9	-0.21					
80		+14.2	_					
70	+ 15.31	_	_					
50	+16.96	+16.3	-0.66					
40	_	+16.8	_					
30	+ 18.61	+17.0**	- 1.60					
20	_	+16.3	_					
16	_	+ 15.4	_					
8		+11.2	_					
4	_	+5.7	_					
2	_	-0.2	_					

*For frequencies above 100 Hz, old and new curves are the same.

TABLE I—COMPARING THE OLD AND NEW RIAA EQUALIZATION curves et specific frequencies.

extended to 20 kHz because recording at this frequency is not only practical but is, in fact, taking place on many current discs. At the high end of the playback curve, however, no change in preamplifier equalization circuitry is required, since the existing 75-µs rolloff network does the job out to 20 kHz and beyond. The curve has simply been extended to recognize points out 20 kHz.

With respect to the low end of the playback curve, adding the fixed rolloff network will make a difference. Table I shows the old and new R1AA bass-boost values from 100 Hz down. Next to these values are listed the difference (in dB) between the old and new equalization curves. Note, for example, that while at 100 Hz the difference is hardly significant (0.2 dB), at 50 Hz it amounts to 0.66 dB, and at 30 Hz (the previous only points).

of the old curve) it is more than 1.6 dB! Such a difference in response may not seem significant, but when you compare the subsonic region of Fig. 6 with the now specified subsonic response of the new RIAA curve, the importance of this change becomes apparent.

In a very real sense, the use of the new playback curve in preamplifiers, integrated amplifiers and receivers should significantly reduce turntable rumble quite audibly. Using the rumble frequency of 7.5 Hz cited earlier, we have already noted that an amplifier not equipped with any form of subsonic rolloff would provide about 24 dB of boost at that low frequency. Based upon the new RIAA curve, boost at the 7.5-Hz frequency will be down to only around 11.0 dB—an improvement of 13 dB at that particular rumble frequency.

Older equipment

Equalization circuit values differ from manufacturer to manufacturer and from product to product (usually, equalization constants are included in a negative-feedback network around the two or three amplification stages contained in the lowlevel preamplifying section of a preamplifier or amplifier). It would therefore

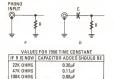


FIG. 8—TYPICAL PHONO INPUT JACK arrangement in the preamplifier stages is shown in a. Simple modification to obtain new RIAA playback equalization is shown in b.

be impossible to advise what new resistor and capacitance values to add to your present preamplifier circuitry so that it conforms with the new RIAA curve. A simpler modification can be made, assuming that the manufacturer of your equipment has no other suggestions or recommendations. As you know, most phono input jacks are terminated with a 47,000-ohm resistor, which magnetic cartridge manufacturers recommend as the optimum load resistance. By adding a high-quality miniature Mylar capacitor of appropriate value, you can easily obtain the rolloff characteristic required by the new RIAA curve. Figure 8-a shows the typical phono input jack arrangement, with the load resistor wired directly across the phono input cartridge. In some instances, you may have to follow the shielded cable to its other end if no resistor is directly wired across these jacks. Figure 8-b shows a small capacitor added in series with the signal side of the load resistor, and the accompanying table in Fig. 8 shows values of capacitance to be used with commonly found load-resistor

It is to be hoped that designers and manufacturers of preamplifiers, amplifiers and receivers will quickly incorporate the new RIAA playback curve in their future products, since it will benefit record reproduction (regardless of turntable equipment). This is an improvement that has been a long time coming. R-E

CCD memories will replace MOS and core RAM's Charge-coupled device (CCD) memories.

while in some cases still being lab-tested, will be the next device adopted by the computer industry. CCD's will replace fixed-head disc storage, particularly lowend floppy discs. The CCD format of storing data is similar to that of mechanical discs, which will simplify its adaptation to present systems.

Texas Instruments and Fairchild are presently shipping samples of 65K-bit devices, while intel Corporation and Motorola have devices that are still in the planning stage. Users will have a choice of three different CCD's, with the first size (65K) large enough to be a cost-effective replacement for mechanical storage units. However

er, it is expected that the main use for the CCD's will be in auxiliary or main-storage applications, completely replacing MOS and core RAM's. Before this can happen, however, entire systems will have to be redesigned to incorporate the CCD's.

Texas Instruments introduced its 6KK Cs ask March Fairchild produced as caled-up version on its earlier 16K devices; and Intel Corporation plans to introduce samples of its 65K device this spring. Motorola will produce a similar device, using Fairchild masks. The Fairchild and TI devices ser organized in 16 x 4K x 1 format (or 16 randomly accessible shift registers, each interference serial-parallel-serial-articutor that keeps power low and operating rate that keeps power low and operating rate.

256 loops of 256 bits each . . . to shorten latency time . . . and is also completely TTL compatible.

All manufacturers agreed that although CDP's will be harder to use than dynamic RAM's, the low-cost factor will dictate the success of the anticipated changeover to CCD's. It is estimated that the de. ces will have a minimum 4:1 cost advantage over RAM's.

The real key, however, to the final acceptance of CCPs, according to one spokesman, will be in standardization of design. At present, both Fairchild and Tiuse 16-pin devices and 16 × 4K × 1 arrays; Fairchild's unit comes in the standard 0.3-inch-wide package, IT's in a 0.4-inch-wide configuration. And Intel uses an 18-pin device in a 0.3-inch-wide package.

^{**}Actually listed as 31.5 Hz in new RIAA curve.

Radio-Electronics Tests Toshiba ST-910 FM Tuner



CIRCLE 101 ON EDEC INCODMATION CARD

LEN FELDMAN CONTRIBUTING HI-FI EDITOR

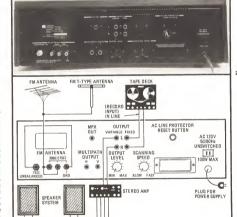
THE TOSHIBA MODEL ST-910 IS THE MOST UNusually configured FM tuner we have ever seen or tested. The front panel (shown in Fig. 1) is completely devoid of knobs and conventional switches, except for a single mechanically operated power on-off pushbutton switch at the lower left of the front panel. Nor is the tuner equipped with a conventional type of frequency dial scale. So, to operate this handsome tuner, you simply touch appropriate points on the large screened glass surface that occupies about two-thirds of the front panel. Along the bottom edge of this glass area are no less than 19 small rectangular areas, each of which contains a touch switch composed of invisible, transparent electrodes. When you touch one of these areas, a small "hum" voltage is developed that signals the all-electronic switches to perform the various tuner

The first three touch-switch areas determine the muting-threshold level. Touch one of these areas and a green light illuminates just above the area. Directly above these three green lights are three tiny red lights, each illuminating at a prescribed signal-strength input. If only the leftmost muting-level switch is touched, then any signals equal to or greater than the level needed to light the first signallevel light can overcome the muting circuitry. If the third muting-level switch is touched, then only those signals that are strong enough to light up all three red signal-level lights can overcome the muting-threshold level. When power is first applied, the first (lowest signal level) muting-level light comes on automatically, and, as we later learned, signals above around 7 µV (22.1 dBf) will be received. All muting can be defeated (for ultra-weak signal reception) by touching the first already-illuminated muting-level switch area, at which time the green light goes out and the tuner is "wide open" regardless of incoming signal strength. However, interstation noise will also be heard when you tune up or down the frequency band.

The four darkened windows to the right of the signal-level indicators display tuned-to frequencies in bright red digits. The tuning range is from 87.5 MHz to 107.9 MHz in 100-kHz (0.1-MHz) increments. Increments of 100 kHz were chosen because even though FM stations in the U.S. are always assigned at 200kHz intervals (i.e., 88.1, 88.3, etc.), this is not

the case in Europe and other foreign coun-

Manual tuning is accomplished by means of four touch-switch areas located beneath the frequency readout windows. The first two switch areas are labeled UP and DOWN, and touching either of them shifts the receive frequency in 1-MHz increments (either up or



MANUFACTURER'S PUBLISHED SPECIFICATIONS:

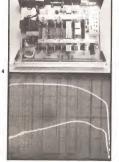
Usable Sensitivity: mono, 1.8 µV. S/N Ratio: mono, 75 dB. Total Harmonic Distortion (400 Hz. 100% modulation): mono, 0, 15%; stereo, 0.2%. Frequency Response: 20 Hz to 15 kHz, ±0.5 dB. Alternate Channel Selectivity: 85 dB. Image Rejection: 100 dB. IF Rejection: 100 dB. Spurious Rejection: 100 dB. AM Suppression: 65 dB. Capture Ratio: 1.5 dB. FM Stereo Separation: 40 dB at 1 kHz. Rated Output Level: fixed, 650 mV (400 Hz. 100% modulation); variable, 0 to 2.0 V (400 Hz, 100% modulation). Output Impedance: 1000 ohms. Power Requirements: 120V, 60 Hz, AC. Power Consumption: 30 watts. Dimensions: 450 mm W X 143 mm H X 340 mm D. Weight: 8 kg (17.64 lbs.). Suggested Retail Price: \$1800.

down). The second pair of touch switches shifts the tuned-to frequency in 100-kHz increments, again either up or down, each time the appropriate switch is touched

Next in line is a touch switch labeled MEMO-RY. Touching this switch turns on a red light above the switch. You then have approximately three seconds to enter the displayed frequency into one of the seven available "sensor" or memory channels by touching one of the available touch-switch areas numbered from 1 through 7. A green light above the selected channel switch comes on, the red light above the MEMORY switch flashes brightly and is extinguished, and the selected frequency is permanently stored in the channel memory of your choice. In the future, to recall that frequency, just touch the appropriate touch switch again, and the frequency is recalled and appears in the readout. The frequency remains in memory even if the power is shut off and the set turned on at another time, just as long as the power plug remains connected to the wall outlet

There is a third tuning method called AUTO TUNING. Two more touch-switch areas, labeled UP START and DOWN START are located to the right of the seven memory switches. When either the UB START or DOWN START switch is touched, the tuner starts scanning frequencies (either up or down) until a signal is received that is equal to or greater than the previously selected muting-level threshold. Another switch area next to these two areas labeled STEREO ONLY permits only stereo signals to overcome the muting circuitry. Activating this switch causes a light to come on just above it to remind you that this mode has been selected. Finally, a touch-switch area labeled MONO, at the extreme lower right-hand corner of the panel, permits you to deliberately alter stereo reception to the monophonic mode, in case stereo signals are too weak and noisy. A stereo indicator above this last switch lights up when stereo signals are received. To return to stereo reception or to automatic mono/stereo switching, simply touch the MONO switch a second time and the light above it goes out.

The rear panel shown in Fig. 2 has screwtype antenna terminals for 300-ohm or 75-ohm transmission-line connection, along with a standard coaxial connector for using 75-ohm coaxial lead-in cable with an appropriate mating connector. Also provided are output jacks for connection to horizontal and vertical oscilloscope inputs for observing multipath reception (and properly orienting an antenna for least multipath interference), and an output jack that delivers a composite detector-output signal. (The latter might be needed if the FCC ever approves four-channel discrete FM broadcasting.) Next come output tacks that deliver fixed and variable audio levels, and below them



TARLEL

RADIO-FLECTRONICS PRODUCT TEST REPORT

Menufecturer: Toshibe

EM PERFORMANCE MEASUREMENTS

Model: ST-910

FMFERFORMANO	E MEMOUNEMENTS	
SENSITIVITY, NOISE AND FREEDOM FROM INTERFERNCE IHF sensitivity, mono: (JV) (dBD) Sol-did quieting signal, mono (LV) (dBD) Sol-did quieting signal, mono (LV) (dBD) Maximum S/N retio, mono (dB) Maximum S/N retio, mono (dB) AM auppression (dB) Image rejection (dB) I'r rejection (dB) I'r rejection (dB) I'r rejection (dB)	R-E Measurement 1.8 (10.3) 3.6 (16.3) 2.8 (14.1) 40.0 (37.3) 80 70 70 1.6 65 100+ 100 100+ 85	R-E Evaluation Good Very good Excellent Feir Excellent Very good Good Excellent Superb Excellent Superb Excellent
FIDELITY AND DISTORTION MEASUREMENTS Frequency response, 50 Hz to 15 kHz (± dB) Hermonic distortion, 1 kHz, mon (%) Hermonic distortion, 1 kHz, stereo (%) Hermonic distortion, 10 Hz, stereo (%) Hermonic distortion, 100 Hz, mon (%) Harmonic distortion, 100 Hz, stereo (%) Harmonic distortion, 100 Hz, stereo (%) Distortion at 50-dB quieting, stereo (%) Distortion at 50-dB quieting, mon (%) Distortion at 50-dB quieting, stereo (%)	0.5 0.08 0.085 0.18 0.17 0.17 1.4 0.45	Excellent Excellent Superb Good Very good Feir Excellent Fair Good
STEREO PERFORMANCE MEASUREMENTS Stereo threshold (µV) (dBf) Seperation, 1 kHz (dB) Seperation, 10 kHz (dB) Saparation, 10 kHz (dB) MISCELLANEOUS MEASUREMENTS MUSIC HARMS (µV) (dBf)	3.6 (16.3) 39 48 29 7, 60, 500 (22, 40.8, 59.2)	Very good Good Excellent Good
Diel celibretion accuracy (± kHz at MHz) EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION	"Perfect"	Perfect

Control layout Ease of tuning Accurecy of meters or other tuning eids Usefulness of other controls Construction end internal leyout

Ease of servicing Eveluetion of extra feetures, if any OVERALL FM PERFORMANCE RATING

Excellent Superb Perfect, see text Excellent Excellent Good Excellent Very good

Model: ST-910

TABLE II

RADIO-ELECTRONICS PRODUCT TEST REPORT

Menufacturer: Toshiba

OVERALL PRODUCT ANALYSIS

Retell price \$1000 Price category High Good Price/performance retio Styling and eppeerance Excellent Sound quelity Excellent

Mechanicel performance

Commants: There is no doubt that e good deal of the cost of this unusual FM tuner has been epportioned to its sophisticated touch-switch operation, its eli-electronic operation and its seven-station memory capability. The eudio purist may regerd some or eil of these features as pure "gimmickry," but at leest one aspect of the novel dasign does contribute to audibly improved FM reception. Thet is the frequancy-synthesized tuning. While it is true that other tuners we have measured cen delivar as low distoras this one (some do even better et the low- and high-frequency extremes), you must beer in mind that those uitre-low distortion results are obteined in our jeboratory using e distortion anelyzar hooked up to tha tuner that anables us to tuna to such minimumdistortion points. The home user rarely, if ever, has that advantage and must usually depend upon less-than-accuretely calibrated center-tune meters. Even slight tuning errors create greet increases in distortion, in the case of the model ST-910, no such tuning errors are possible. What you read on the digital readout is whet you get-in frequency, that is. As for the novel touch-switch operation, it certainly does land an air of elegence to the tuner and, as Toshibe points out, purely electronic switching of this type is not subject to weer or "dirty contacts" with extended use. On the other hand, such refinements do not, in and of themselves, contribute to better FM sound. At this price level, too, we would have expected to find some built-in maans for indicating multipath distortion rather than having to use en externally connected oscilioscopa

is an output-level control. A second matching knob varies the scanning speed of the autotuning mode, as described previously. A line according to the convenience AC outlet with 100-watt capacity complete the rare-panel layout. The dula pairs of output jacks permit you to connect a tage deck directly to the fixed output jacks while the variable output jacks can be connected to the amplifier, as shown in Fig. 3.

Internal construction and circuitry

Figure 4 shows the internal layout of the model ST-910 and, as might be expected, the parts density is extreme. To give you some idea of the complexity of the frequency-synthesis tuning system and its associated memory circuits, the model ST-910 contains 32 transistors, 9 FET's, 100 diodes, 11 linear IC's, 85 digital IC's and 24 LED's!

The linear portions of the tuner include two RF stages using cascaded FET's and varicap diodes for front-end tuning. The IF section contains LC filtering (multipole) and a broad-hand ratio detector. Phase-locked-loop circuitry is used in the multiplex decoder section.

Performance measurements

Table I summarizes major laboratory performance measurements, only a few of which can be compared with the manufacturer's specifications that are quite sparse for a tuner of this quality. Nevertheless, in absolute terms. the tuner's measured performance, although not quite as good as that of the highest-quality conventionally designed tuners we have measured, is more than adequate for good reception under most listening conditions. Distortion at midfrequencies was, in fact, excellent in both the mono and stereo modes, but tended to rise a bit too rapidly at the low- and highfrequency extremes. AM suppression and other rejection specifications were superb, however, and it is these lesser specifications that often make the difference between a very good tuner and an excellent one.

A plot of separation-versus-frequency is shown in Fig. 5, with the upper trace representing the response of the tuner to the "desired" channel (including 75-µs de-emphasis) and the lower trace showing the output from the opposite stereo channel under the same modulating conditions.

Use and listening tests

The model ST-9/0 is a joy to use. On occasion, we did not that touching certain touch-switch areas did not immediately activate the corresponding switching function. However, we found that this problem was immediately corrected by gripping the front panel with the other hand. In any case, it takes only a few minutes to become familiar with the unit's novel switching arrangement and memory cactivities, and the control of the control of the control of the corresponding to the control of the companying noise, clicks or pops so often associated with some mutual pricavitis.

A summary of this product will be found in Table II, together with our overall product evaluation. Certainly, the model \$S7-910 is a great engineering accomplishment and we can easily understand why it is so costly. The well-heeld audio hobbyist may find this tuner hard to resist, especially after playing with its touch playing with the touch the state of the state

R-I

U.S. Pioneer RT-707 Tape Deck

LEN FELDMAN

CONTRIBUTING HI-FI EDITOR

THOSE READERS WHO ARE OLD ENOUGH TO remember some of the first open-reel tape decks designed for home use many years ago will experience a feeling of deia vu when they see the new U.S. Pioneer Electronics model RT-707 open-reel tape deck shown in Fig. 1. The wide, rack-mountable square shape resembles some of the old Magnecord decks popular some time back, and lends itself beautifully to home installation on a shelf or table top, unlike some tall, top-heavy open-reel units presently on the market. Don't be misled by appearances, however. The model RT-707 is a modern and sophisticated open-reel machine, and, at its unusually low suggested price, may appeal to those serious home recordists who might otherwise purchase a cassette deck.

The tape deck's low profile does, of course, limit reel size to a 7-inch reel (even these reels project a bit above the top of the unit). But with the available speeds of 7½ ips and 3¾ ips, maximum recording time is as great as might be obtained with 10-inch reels at twice the speed. With the excellent frequency response and high signal-to-noise ratio available at the 7½-jips speed, there is really no important loss in performance compared with the higher pressional 15-jips speed machines—especially in view of the low wow-and-flutter figures obtainable at the 7½-yins speed.

Controls near the top of the deck (between the reels and surmounting the twin recordlevel meters) include a power ON-OFF pushbutton, a speed selector pushbutton, a TAPE/ SOURCE monitor pushbutton, BIAS and EQ pushbuttons and individual left- and rightchannel record pushbuttons. Wide-throw meters are calibrated from -20 dB to +3 dB. Between the meters are RECord and PAUSE indicator lights; while below the meters are a four-digit counter, a RESET control, a REPEATplay pushbutton and a pitch-control knob that varies playback speed by approximately ±6%. Since this machine can be operated in either direction, it comes with four tape heads (record, erase and two playback heads). The playback heads and the record head are made of hard Permalloy, while the erase head is made of ferrite. The heads are protected by a metal cover, with screw holes provided for azimuth

 adjustment of both playback heads and the single record head. Quarter-track configuration is supplied.

Beneath the supply reel are two microphone input jacks, a stereo headphone output jack, a dual concentrically mounted microphone input and line input-level controls. Beneath the take-



up reel on the right are a a PAUSE pushbutton, fast-forward and fast-rewind pushbuttons, STOP pushbutton, PLAY and RECORD pushbuttons, and a pair of pushbuttons with arrow lights indicating the direction of tape travel.

MANUFACTURER'S PUBLISHED SPECIFICATIONS:

Maximum Reel Sizez / Inches. Speeds: 7½ (ps and 3½ (ps. Speed Accuracy: ±0.5%, Feat Rewind Time: 1200 feet, approximately 100 seconds. Wow and Fattlers: 7½ (ps. 0.05% WRMS); 3½ (ps. 0.05% WRMS, S/N Ratic better than 56 dB (referenced to a 16-dB record level). Harmonic Distortion: 16ss than 1.0% at 7½ (ps. Frequency Response: measured at -20-dB record level, 30 Hz to 24,000 Hz, ±3 dB at 7½ (ps. 16) at 10 Hz to 16,000 Hz, ±3 dB at 3½ (ps. Creastalk and Stereo Separation: better things of dB. Erase Coefficient: 70 dB. Bias Frequency: 125 kHz, Input Sensitivity: mike, 0.25 wr (125 mV maximum), line, 50 mV 22 dbs mod-o-thin loads. Power Requirementa: 120 volts, 50°Lo 60 Hz, 120 watts maximum. Dimensions: 189½ W X 9½ H X 14½ D. NEW Weight 43 lbs., 10 cz. Suggested Retail Price: \$575.

Drive system

The model RT-707 uses three separate drive motors: A frequency-generating AC servom-tor drives the single-capstan tape-drive system while two 6-pole inner-rotor induction motors handle reel rotation in both the play and fast-wind modes. A large flywheel is associated with the tape-drive motor. The motor is consisted from mode to mode without giong through STOR. This same feature also permits you to rook the transport system between fast forward and fast rewind for locating specific points on a tape smoothly.

Figure 2 is a scope photo of the record/ playback response at the 71/2-ips speed, using record levels of 0-dB (upper trace) and -20dB (lower trace). Note that even at the high 0dB record level, response just begins to roll off at the 20-kHz extreme, while at the lower, -20-dB record level, the response is flat to beyond the 20-kHz sweep limit. Of course, this is one of the key advantages of an open-reel machine as compared with even the best tape cassettes. In the latter, any attempt to record a 20-kHz frequency sweep at 0-dB record level results in extreme tape saturation and extensive rolloff at the high end.

Figure 3 shows some evidence of this effect. In this test, the slower 31/4-ips speed was used, and three frequency sweeps were measured and displayed on the scope face. The upper trace shows the 0-dB sweep, -10 dB and -20 dB (in the bottom trace). When this slower speed is used, the greater amount of treble equalization during recording does result in tape saturation at the higher record levels, but at the -20-dB record level, the response extends to above 16 kHz.



Harmonic distortion was generally much lower than would be obtained at equivalent record levels using a high-quality cassette deck. And, of course, the 64.5-dB signal-tonoise ratio (referenced to the 3% THD record level, or +10 dB) was observed without the aid of any separate noise-reduction system such as Dolby.

Summary

Our overall product evaluation together with comments are shown in Table II.

Pioneer has produced a fine open-reel machine at a relatively modest price that gives the serious home recordist on a limited budget a real choice between a cassette and an open-reel instrument.

TARIF 1

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: U.S. Pioneer F

-1001101				Middai: H1-707
REEL	TAPE	DECK	MEASUREMENTS	

FREQUENCY RESPONSE MEASUREMENTS	R-E	R-E
STANDARD TAPE	Meesurements	Eveluation
Frequency responsa at 15 lps (Hz-kHz, ± dB)	N/A	N/A
Frequency response at 71/2 ips (Hz-kHz±dB)	21-21.3	Excellent
Frequency Response et 3-3/4 ips (Hz-kHz±dB) CrO ₂ TAPE	29-16, 3	Very good
Frequency response at 15 lps (Hz-kHz, ±dB)	N/A	N/A
Frequency response at 71/2 ips (Hz-kHz, ±dB)	N/A	N/A
Frequency response at 3% lps (Hz-kHz±dB)	N/A	N/A
	(See Figs. 2,3)	
DISTORTION MEASUREMENTS (RECORD/PLAY)		
Hermonic distortion at -3 VU (highest speed) (%)	0.6	Very good
Harmonic distortion at 0 VU (highest speed) (%)	0.7	Excellent
Harmonic distortion at +3 VU (highest speed) (%)	0.8	Excellent
Record level for 3% THD (dB)	+ 10.0	Excellent
(+ 10.0	Excellent
SIGNAL-TO-NOISE RATIO MEASUREMENTS		
Best S/N ratio, standerd tape (dB)	64.5	Excellent
Best S/N ratio, CrO ₂ tape (dB)	N/A	N/A
MECHANICAL PERFORMANCE MEASUREMENTS		
Wow end flutter at 15 lps (% WRMS)	N/A	N/A
Wow and flutter at 71/2 lps (% WRMS)	0.045	Excellent
Wow and flutter at 31/4 lps (% WRMS)	0.06	Superb
Rewind time, 1200-foot tape (seconds)	65	Good
COMPONENT MATCHING CHARACTERISTICS		
Microphone input sensitivity (mV)	0.2	
Line input sensitivity (mV)	44	
Line output level (mV)	440	
Phone output lavel (mV or mW)	73 mV/8 ohms	
Blas frequency (kHz)	73 mV/8 onms 125	
	125	
TRANSPORT MECHANISM EVALUATION		
Action of transport controls		Superb
Tape guidance system		Very good
Absence of mechanical noise		Excellent

TABLE II

BADIO-FLECTRONICS PRODUCT TEST REPORT

Manufacturer: U.S. Pioneer Electronics

OVERALL TAPE DECK PERFORMANCE RATING

nstruction end Internal layout Evaluation of extra featuras, If any

Tepe head accessibility

OPEN-

Model: RT-707

Very good Excellent

Excellent

Excellent

OVERALL PRODUC	T ANALYSIS
Retail price	\$575
Prica eategory	Low
Price/performance ratio	Excellen
Styling and appaarance	Superb
Sound quality	Very goo
Mechanical performanca	Excellen

Comments: In recent yeers, most open-reel tepe deck manufacturers have been catering to supposed needs of semiprofassional home recordists; those who simply want to record and listen to music on tape just for sheer listening pleesure have had to opt for better-quelity cassette decks. High-priced open-reel decks of rather large proportions have generally been the rule. Pioneer has changed all that with this unusual open-reel machine. The model RT-707 fits nicely on a shelf along with other components. All the advantages of an opan-reel unit (easy aditing, higher dynemic range and better signs to-noise ratio compared with even the best cassettas) are ratained, plus e few extra features that may be received with indifference by the "pro" recordist but will be much appreciated by the home user. These include the auto reverse playback feature, the rapeat-pley option (using sensing tapa at one end of the tepe and the 0000 setting of the tape counter as cues for tha logic control system) and the pitch control, which Insurea in-tune pleyback of tapas made on other, less-then-perfect-speed recorders. Considering the going prices of competitive open-reel decks, we found it elmost unbelievable that Pioneer was able to provide three-motor direct drive logic-actuated transport systems for the relatively low price indicated. Separate control of left- and right-channel recording provides even more flaxibility and permits sound-on-sound recordings (by changing rear-panel amplifier patching). With response to well beyond 20,000 Hz in the high-speed mode, this open-reel machina outperforms cassette decks costing considerably more. Its mechanical and electrical performance, as well as its imaginative physical configuration, is likely to prompt many a prospective recordist to consider going back to open reel instead of settling for a cassette deck.

Selecting A DMM-

What you should look for



If you think you know everything about DDM's, you probably don't. So, let's follow the trials and tribulations of George Tinkerer after he's bought one.

MARSH FABER*

THE LOUD RING OF THE DOORBELL BREAKS the silence.

"I'll get it!

George Tinkerer bounds down the stairs, throws open the door and greets the mailman like a long-lost brother. "It's here, Blanche! It's here!"

"What's here, George?" his wife an-

swers.
"My new DMM! My new Whoopeetronics automatic dual-sensing, parametrically perambulating, 65-function, three-

phase voltmeter."
"You mean you spent \$294.68 of Junior's future college fund for that?"

George ignores his wife's subtle prod as his trembling fingers unveil the prize. George savors every second with superhuman restraint. Ever so slowly, he uncoils the power cord and dramatically inserts the plug into the wall receptacle. The box responds with an impressive display of red zeros.

"Big deal, George. What does it do?"
"It measures volts, ohms and am-

peres."
"Fantastic. So what's a volt, George?"
"A volt is one of those things that

comes out of the wall. I'll show you."
"Don't you think you better read the
manual first, George?"

"Nah! Manuals are for amateurs. Look, you just take these probes and stick them in the wall socket, like this."

Of course, George Tinkerer's Whoo-

pee-tronics prestidigitator isn't ready to read 115 volts AC. In fact, it is eagerly looking forward to telling him what value resistor he might have in his hand.

As George applies his house current to the ohms input, the DMM responds predictably by smoking, arcing, hemorrhaging internally; it raises itself three inches off the bench and self-immolates. George is thrown to the floor, Blanche is scared out of three inches of baby fat and the new toy lies groaning and smoldering on George's blackened workbench.

Following the \$294.68 holocaust, George regains his wife's good graces by babysitting eight Saturdays in a row, dropping out of the bowling league and cleaning up the garage—not once, but twice. George's true cost of owning a DMM is more than any man should have to pay.

George's plight is less fantasy than fact. The initial purchase price of a DMM may be irrelevant compared to the cost and hassle resulting from the abuse of poorly designed protection circuitry.

George is a charter member in the most difficult customer group that a DMM manufacturer must cater to. As recently as ten years ago, DMM's were available only to a select few people supported by corporate research budgets. They were expensive and hardly portable; and they were designed for the sophisticated user who demanded the ultimate in accuracy.

Today, DMM manufacturers cater to

George. They produce small, portable instruments, at reasonable prices with the emphasis on durability. George may not have as much training and experience as a man in a standards lab, but he is much more demanding. When he makes a mistake in using his DMM, he expects the instrument to shrug off the overload and "keep on ticking."

In order to design a multimeter that is

within George's price range, the manufacturer must make engineering tradeoffs. The consumer must therefore beware of enticingly low price tags and consider the compromises that may have been made. The initial cost, usability, serviceability and dependability must all be considered.

Initial cost

The most obvious cost in owning a DMM is the purchase price, which is the amount that usually headlines the advertisement for the instrument. However, this amount may not include the cost of necessary options or attachments.

Always obtain a data sheet before ordering any piece of equipment. Often an accessory is listed on the data sheet that you must add to the instrument before it is capable of performing your desired measurement.

Such options and accessories include batteries, chargers, carrying cases, various probes and test leads. External accessories, such as probes, are easy to order at a later date, but some options may be

Usability

George Tinkerer had a specific application in mind when he bought his multimeter. Had he not destroyed it upon receipt, he would have eventually judged its usefulness by how well it performed in his measurement application. George wanted a DMM that met his requirements, but he didn't want to pay extra money for capability that he would never use.

In order to receive the best return on his investment, George should have scrutinized and understood the data-sheet specifications. The most fundamental data-sheet specification are often misinterpreted. Resolution, sensitivity and accuracy characterize the fundamental capability of any DMM.

The overrange capabilities of DMM's vary widely, and their labeling can often be ambiguous. Technically, the number of digits a DMM can display is the logarithm of the maximum reading (number of counts). For example:

ed
n
ligits

Some definitions take the \pm sign into account, which doubles the number of total counts and adds 0.3 digits to the Log₁₀ \times value. Thus, a \pm 1999-count DMM becomes a 3998-count DMM, and Log₁₀ 3998 = 3.6 digits.

This is all delightfully confusing and of little interest until you attempt to measure a 15-volt supply with some accuracy and find that the reading is 15.0 on one DMM when it could be 15.00 on another DMM, the latter instrument having better accuracy.

The solution to the "number-of-digits" enigma is to look only at the total number of counts, or the overrange specification.

In a 3-digit DMM, 1000 counts is full

scale and any count above that figure is considered to be overrange.

	Overrange
1000	0
1999	100%
2999	200%
	1999

While the labels are not necessarily exact, the total maximum reading will always give the true resolution—the ability to detect a small incremental change in a signal. If a 3½-digit DMM displays 0 to 1999 counts, the resolution (one count) represents one part in 2000, or .05%.

Sensitivity is the quantity measured by the least-significant digit on the lowest range. If the full-scale reading on the most sensitive range is 199.9 mV, the sensitivity is 1 mV, or 100 μV. Similarly, if the lowest ohms range is 19.99 ohms, the sensitivity is .01 ohms, or 10 milliohms.

There are many cases where accuracy is not a prime consideration, but in those special instances where it is, it is useful to know the difference between full-scale accuracy and one-tenth-scale accuracy. Even a specification as fundamentally important as accuracy can be ambiguous. Here are two examples:

+ 1 count
For a 1000-count DMM, both specifications are identical, but assume both are
2000-count instruments, and look at the
error for a 15.0-volt input on the 200-volt

= 0.215 volt
DMM (B)—Error = 150
$$\times$$
 0.1% + 1
count
= 150 \times 0.1% + 1

count
= 0.115 volt
Expressed as a percent of reading.

expressed as a percent of reading, which is the true measure of accuracy for any input, the errors are:

DMM (A)—% error =
$$\frac{0.215 \text{ volts}}{15.0 \text{ volts}}$$
$$= 1.43\% \text{ of reading}$$
DMM (B) $= 3.115 \text{ volts}$

DMM (B)—% error =
$$\frac{.113 \text{ volts}}{15.0 \text{ volts}}$$

= 0.77% of reading

Clearly, the percent-of-range error has a drastic effect upon the accuracy of a low-level measurement. Conversely, for best accuracy, the DMM range switch should be set to display the maximum number of counts. In the worst case shown above, DMM (A), which netted a 1.43%-of-reading error, assume the DMM is set to a lower range, from 200 volts to 20 volts.

= 1.5 + 2 = 3.5 counts = .035 volt

As a percent of reading, this becomes:
% reading error =
$$\frac{.035 \text{ volt}}{15.00 \text{ volts}}$$

= 0.233%

This percent-of-reading error is a considerable improvement over 1.43%. It is interesting to note that the most accurate reading that can ever be made by either DMM (A) or DMM (B) is 0.2% of reading. At any voltage below full scale, the

effective accuracy decreases. This is particularly true for AC voltage measurements. The most common AC converters use either logging amplifiers or diode switches; both techniques exhibit poor performance near zero. Again, the most accurate measurements are made at full scale.

Features

Once decisions regarding resolution, sensitivity and basic accuracy were made, George Tinkerer was faced with a new set



FIG. 1—OHMS CONVERTER consists of constant current source feeding the unknown resistor.

of choices labeled "convenience factors."
He went over the list and checked off "current," "autoranging," "battery power" and "LCD." George mistakenly thought that "LCD" stood for "liquid crystal display" when, in fact, it meant "lizard crossing detector." (This option proved to be of marginal value to George who was a strict vegetarian!)

Preposterous? Yes, but some features appear better on paper than they do on the bench. Autoranging is an example. Some DMM's incorporate a switchable XI or XIO amplifier that allows autoranging on only two ranges. This reduces the number of manual range-switch positions, but it does not offer full autorange capability.

Full autoranging almost guarantees input protection. Some manually ranged DMM's offer limited overvoltage protection on the lower voltage ranges, but an autoranged instrument, by the very nature of the design, must accept the full input voltage (for instance, 1000 volts) on the lowest range.

inte towest range. The little state of the control of the control

The ohms conversion offers more opportunity for confusion. The ohms converter is the circuit (see Fig. 1) that supplies a constant current to an unknown resistor. Its output is a voltage that is measured by the A/D converter and displayed as an ohms reading. ing way of indicating overload.

TYPICAL LED DISPLAY is easier to read then LCD diepley but it consumes more power.

input should be displayed so distinctively that it cannot be interpreted as a valid

reading. Smoke pouring from the front

nanel is generally considered an unsport-

Service

The day is bleak . . . the wind is cold . . . the sky is overcast. George is overcast. He steps off the bus and pulls his collar high to fend off the freezing rain. Under his left arm, he carries the decimated remains of his DMM. Every slipnery footstep on the rain-slicked sidewalk brings him closer to the Whoopee-tronics service center. He recalls the embarrassment of that infamous day when his DMM failed him. In his mind's eye, he can envision the Whoopee-tronics showroom full of ex-used car salesmen in checkered sport coats and polka-dot ties with big toothy grins that seem to say, "hello, sucker,

By the time he reaches his destination. George is livid. White knuckles squeeze the doorknob into submission as his wet shoes soil the polished tile floor. His temples start to pound and his already crimson neck starts turning purple as he approaches the service desk.

Hi, pops. You look like a drowned rat." After making the remark, the service technician notices blue flames emanating from George's nostrils and decides to back off. Finally, George speaks.

"You turkeys sold me this blanketvblank instrument and it blew up, and I want to know what you're going to do about it!" The technician manages a weak smile as he extracts the DMM from George's midsection.

"Hmmmm, looks like the ohms converter. I can tell because there's a little puddle of metal where the protection transistor used to be. Heh, heh." The levity goes unanswered. "Well, let's just try a new input module." As he applies power, the DMM returns like a phoenix to the living world. "Now, I'll calibrate it for you," The technician adjusts the controls, returning the instrument to its original condition. George is impressed, but still defensive.

"O.K., what's this gonna cost me?" "Oh, nothing. We've corrected a design flaw in our ohms protection circuit, and we now list an ohms overload specifi-

cation in our data sheet. I'm glad you bought our DMM instead of an analog meter. An ordinary analog meter needle would have wound around like a pig's tail and it would have been cheaper to replace the whole instrument than to pay for the repair. Imagine how many pointers you could corkscrew around the stop in, say, five years. At \$70 apiece, you could easily instify buying a dandy self-protected, accurate autoranging DMM. Of course, we can't promise ours will never fail, but we are doing everything possible to make ours dependable. In any case, please try to

George feels like the guy who was under the bleachers ordering a hot dog when Hank Aaron hit his 714th homer. He came prepared for a fist fight and couldn't find an opponent. Suddenly, his opinion of Whoopee-tronics is reversed. He starts thinking about why the service is so good. He notices the quiet efficiency of the service center and recalls the service technician's skill. George realizes that the technician hardly looked at the manual when he calibrated the DMM because the order of adjustments and their relationship to each function had been clearly marked on a piece of sheet metal inside the DMM. The workmanship was excellent, and a drawing of the PC board in the manual allowed instantaneous component location. The manual contained detailed schematics and troubleshooting aids.

George is impressed with the service he obtained and appreciates the time and effort that go into making a product serviceable, but he wonders now how dependable his DMM will be in the future. He asks the service technician what steps Whoopee-tronics takes to guarantee reliability.

The technician first explains that George's mishap will be less likely to occur in the future due to some new abuse tests recently implemented by Whoopee-tronics. He proudly recites the company viewpoint on dependability:

Dependability

"Dependability is the characteristic that separates the quality instrument from the average instrument. It is a direct measure of design forethought.

"Even the most knowledgeable user will err at times in his application and unintentionally subject his multimeter to adverse conditions. A properly designed multimeter would have survived your debut into the rewarding world of electronics without so much as a whimper.

There are some unavoidable adverse conditions, such as physical and electrical environments. Most 'expensive' multimeters undergo a strenuous series of environmental tests before designs are finalized, and the designs are often changed as a direct result of these tests.

"The more common environmental

In an analog meter, the current source does not have to be constant because any arbitrary linearity function can be displayed by simply changing the markings on the meter scale. However, a DMM uses a linear A/D converter, so the current must be constant. Sometimes an ohms converter will be

specified as having a "5-volt maximum output." This does not mean that the ohms converter can send 5 volts across a low impedance. On the contrary, it simply means that the current-source output is limited to 5 volts. In no case will the current source supply more than its listed

tuted when DMM's were manufactured for the armed forces. Because most active devices are damaged by current and not by voltage, the most important specification to consider is not the maximum output voltage, but the maximum output current that the ohmmeter can supply.

Display

When George checked off LCD on the data sheet, he really wanted a liquid crystal display. He was probably interested in long battery life. Liquid crystals offer exceptionally low current drain, and they can be manufactured with any number of different display characters. Some LCD's are very slow at cold temperatures, sometimes taking as long as half a second to change states completely, and certain other types encounter reliability problems in humidity at elevated temperatures. Since LCD's are slow, they are hard to multiplex, so the number of interconnections becomes quite high. They must be back-lighted to be seen in a dark room and certain types suffer from a narrow viewing angle.

Light-emitting diode displays (LED's) are fast enough to multiplex, and they offer more consistent temperature performance than liquid crystals. The LED is difficult to read in very bright sunlight, while the LCD is not. The LED is fast, but it also consumes more power. In order to reduce power requirements, I ED's are sometimes made smaller and placed behind a lens, but this also restricts the viewing angle. LED displays are manufactured in predetermined sizes and shapes, and do not offer the displaycharacter flexibility afforded LCD's. However, LED's are reliable under adverse environmental conditions.

In addition to obtaining accurate readings, George is also concerned with interpreting those readings. He wants full annunciation to lessen possible error. If an instrument is properly annunciated, the user should be able to glance at the display and know immediately that he has chosen the correct function and range, and that he has committed no error setting up the front-panel controls. A reading that exceeds the full-scale range

tests include operating temperatures like

FIG. 2—STATIC DISCHARGE from the human body can be represented by this equivelent circuit.

"An entirely new set of tests has been devised to counteract the possible mishandling of a DMM. Every possible misuse of the product is simulated. Instruments are subjected to a current-limited static discharge of 15,000 volts to any exposed terminal. Voltages of over twice the input rating are applied to the input terminals, and extremely high currents are applied to ampere terminals to check for safety and fire hazards. A 230-volt supply is applied to the 115-volt line input as well as to the ohms input to see that no damage occurs. High voltage is applied to the input while selecting every conceivable combination of pushbutton or rotary-switch positions to insure that turning on a switch between positions or pushing buttons in illegal combinations will not cause damage to the instrument or to your circuit.

"High voltages are applied between circuit low and safety ground to check the transformer and all mechanical spacings for dielectric strength. If you wonder why we subject the voltmeter to inputs as extreme as 15,000 volts, this voltage simulates the static discharge from a human body.

Static discharge

"When MOS (Metal Oxide Semiconductor) devices first became available, it was found that they had a high failure rate with respect to other semiconductor technologies. Some clever detective work revealed that the failures were due to static discharge. Since the FET gates had extremely low leakage currents, they could accumulate charge to the point that internal breakdown occurred, destroying the device. Vast improvements have since been made in MOS circuit protection, but these devices are still susceptible to static discharge.

"Contrary to popular belief, MOS integrated circuits are not the only semiconductors that are susceptible. Junction FET's and even bipolar transistors are frequent victims of this phenomenon. This is especially true in voltmeter input circuitry. In order to provide good common mode rejection and minimum voltage drift with changing temperature. DMM manufacturers use differential transistors in input amplifiers. Temperature tracking dictates a small junction area, which makes the device vulnerable to static discharge destruction.

"If you've ever lived in a dry climate. I'm sure you've experienced walking zeross a carpet and drawing an arc to the nearest grounded object. The potential static discharge from your body can reach 15,000 volts under such conditions. Many electrical models have been used to simulate the human body during static discharge. For example, here's one widely accepted model."

The technician draws the schematic shown in Fig. 2 for George.

"Theoretically, 15 amperes of instantaneous short-circuit current can be supplied by this circuit."

George breaks in: "Fifteen amperes?
Hogwash! Why, you would die every time
you touched a doorknob!"

"Certainly, \$5 amperes of continuous current passing through your heart would cause instant fibrillation. However, the current is not continuous and it doesn't pass through your heart.

"The charge is stored on your body's usrface and is discharged over that surface. The only place that the charge pentrates the skin to any extent is at the point of contact with the grounded object, where the increased current density causes pain. Since the time constant of the equivalent circuit is only 300 ns, the energy released is relatively small, but it is enough to damage a semiconductor.

"The design engineer must create an input amplifier that measures microvolts but not be damaged by tens of kilovolts. One method of controlling static is to intentionally design spark gaps around the input circuitry.

"A spark gap can be formed by the lagged ends of two hookup wires or by the blades of a switch wafer. A needle gap arcs at a voltage that is about one-tenth that of two equally spaced smooth surfaces. Because of the physical variations in designing spark gaps and the unpredistability of static discharge, circuit layouts must nearly always be modified empiriically. In the early stages of designing to avoid static damage, this "lightning boil test" may destroy a large section of input circuitry. Troubschooting and replacing the zapped circuit can involve considerable time and effort."

"Gosh," George comments, "I didn't know a static discharge could cause so much damage. But what about my multimeter? Why did it blow up?"

The technician casts a suspicious eye at George. "You probably applied the line voltage directly to the ohms terminals." George's sheepish grin gives him away.

"Yeah, I guess I wasn't very careful," he confesses.

The technician pats him reassuringly on the shoulder. "I wouldn't be too ashamed. All of us have done it at one

time or another. That's exactly what we try to avoid with our new testing program. Our new ohms converter can take the full-line voltage without being destroved.

"Let me show you a simple ohms converter." The technician draws the circuit shown in Fig. 3.

LET R_X REPRESENT THE UNKNOWN RESISTOR, AND R_I REPRESENT THE RANGE RESISTOR INSIDE THE OMM. FOR AN IOEAL OPERATIONAL AMPLIFIER,

$$\begin{aligned} & i = 0 \\ A = \infty & \\ \text{THEN} & \frac{V_{REF} - \epsilon}{R_I} = \frac{\epsilon - V_o}{R_X} \\ \text{BUT} & \epsilon = \frac{V_o}{A} = \frac{V_o}{\infty} = 0 \end{aligned}$$

FIG. 3—SIMPLE OHMS CONVERTER provides output voltage proportional to unknown resis-



tance.

FIG. 4—APPLYING LINE VOLTAGE to input terminels of circuit in Fig. 3 will destroy empli-

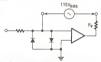


FIG. 5-DIODES PROTECT ohms converter circult against application of line voltage.

"The voltage is proportional to the unknown resistor. Now, assume you apply 115 volts RMS across the ohms terminals. The circuit looks like this." (See Fig. 4.)

"An ordinary operational amplifier would be reduced to cinders, therefore, some protection circuitry is added." (See Fig. 5.)

"Resistor R, protects the op-amp to some extent. However, R, itself now becomes subject to burnout. The value of R, must be small enough to allow the op-amp to supply high current on the lowest resistance range, but this small value means it will dissipate a lot of power if 115 volts AC is accidentally applied to the ohms input. High power usually means a metal-film resistor should be used, but in this case a carbon-composition resistor would probably perform

continued on page 118

1 66

Make Your Own

CUSTOM HARDWARE

These days, it appears that the active electronics experimenter needs a greater variety of hardware just as sources seem to be drying up.

Why not make the hardware you can't find or afford?

JAMES E. TEMPLE

LIKE MOST READERS OF RADIO-ELECTRONICS, I WANT TO build 50% of all construction projects described in each issue, within their specifications and with "hardware to suit." But, to sait what? Certainly not my pocket book. If I buy a minimum quantity, I have to pay a king's ransom to complete the project; if I purchase the standard quantities all that extra hardware sits in my parts boxés. Ah, then the idea lamp lights up: I'll modify the hardware to suit special purposes. So I'dlike to share my experiences on how I successfully modify specialty hardware and make it twice as versatile.

Some necessary tools

The Dremel Motor tool and its many accessories is very versatile. The 1-in-ch-dimeter cutoff wheel with its mandre holder is a fantastic item. The wheel is no more than a 1/4-inch thick, made of a carbide material and a powerful cutter. It is somewhat brittle, especially with any side pressure. Yet it will cut through stainless steel as if it were butter. When it comes to cutting epoxy boards, the cutoff wheel again acts very smoothly. I am impressed with how quickly it cuts, and I try to grind each wheel down to the smallest possible size without breaking the disc. Wear safety glasses as a precution. Since the tool truvels at 24,000 rpm, a breaking disc can send particles all over the place, especially toward your face and eyes.

Jewelers' files also come in handy, as well as a miniature anvil along with a small vacuum vise, emery cloth, pliers, cutters, and any other time-saving tool.

Star No. one

(I refer to any item that cuts down on time and expense as a "star," and feel perhaps you might agree. The miniature tubular terminal, model 1236 by Keystone Electronics Corporation, 49 Blecker St., New York, NY; is able to hold searely wires from 0.010 to 0.050 in diameter, discrete components that can be inserted from either side of the terminal. They mount in a Visinch hole (0.062 to 0.067) with a special insertion tool for hand usage. The terminal comes in quantities of 100 and 1000 and is ideal for both printed circuits, rast'-next-type of building and even Wire-Wrap setups. Figure 1 shows how it would normall be used when inserted into a board.

To modify this little gem, drill the hole and insert the terminal with the tool. Figure 2 shows what happens when you cut it flush with the board, with the cutoff disc. The dotted lines indicate the material removed by cutting. There is no excessive material above the board and the top section has been hammered tightly down to the board (use a light tack hammer). The burrs have been cleaned out with a round jewelers' file, so the miniature tubing has been made even smaller.

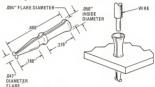


FIG. 1—MINIATURE TUBULAR TERMINAL fits snugly into 1/11-inch hole and can be used for component or wire connection.



FIG. 2—HOW FLUSH-MOUNT SOCKET CAN BE MADE by removing the top part of a miniature tubular terminal and peening over.

What do you use this type of modified hardware for? Have you ever purchased large-size 0.0800 seven-segment LED's for a project, spent a small fortune for each, and just did not relish the idea of soldering them directly to boards or felt that socket mounting just did not fit the project? Well, next time try these tubular terminals, cut flush and matched up to the display leads;

each display is held firmly as if in a socket. With leads A to G, you can now use a minimum number of displays mounted without soldering to avoid possible damage. You can even remove them quite freely to use in another circuit without too much trouble.

Another use for this terminal (cut flush again) is to mount individual LED's without soldering the LED's directly to the board. You will need Vector's T-46 push-in pins, which are This pin has a rounded head, a crimped flange and fits a 0,042 drill hole. Remember the special tool to insert the tubular terminals? When you mount it in a vise upside down, it becomes a miniature setting tool supporting the PC board around the drill hole that will have a pin inserted into it. Merely place the board over the tool, line up the hole, insert the pin and, using a light hammer, hammer it home securely. Solder the round head to the circuit on either side to be sure of circuit continuity. Soldering is an easy way to set these pins. You can also try pushing the pins into the board holes with a pair of pliers. But the pins bend too easily this way.

With this type of LED mounting use the LED lens produced by James Electronics of 1021 Howard Ave., San Carlos, CA. This lens holds the LED securely, and the LED leads can be tied into the circuits. The holder fits a ½-inch hole, and does indeed hold the LED snugly. However, the LED leads must still be soldered to the circuit in which it will be used. Now we have the three parts that can be combined to make a neat and easily dismantled unit: the LED lens and holder, the Vector pins and the miniterminish.

Figure 3 shows a 1-inch long by 1/s-inch wide LED mounting

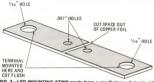


FIG. 3—LED MOUNTING STRIP made from a small piece of single-aided printed-circuit board. Mini-terminals fit the outer holes.

board made of copper foil. At the outermost points of the strip, drill two 1/16-inch holes, one on each end. In the direct center, drill two 0.041 holes spaced 0.100 apart. In between the holes, cut the copper foil in the center to make upper and lower sections that are electrically isolated from each other. Mount the miniterminals in the 1/16-inch holes. Use an anvil as a support to the board when you insert the terminals and push them all the way in. Cut off the excess tubing except for at least 1/16 of an inch, which can be spread apart with a nail and hammered flush with a tack hammer. Clean the holes for burrs with a jewelers' file and insert a wide needle to be sure the holes are open all the way. Where you want to mount a discrete LED, take the pattern strip and mark the centers of the 1/16-inch holes where the minitubes are. On the printed circuit board drill a 0.042 hole. At the dead center of these two holes, mark the board and drill a 1/4inch hole (see Fig. 4). Leave room for the current-dropping resistor for the LED in the vicinity of the 0.042 holes, and be sure of the polarity of the line the resistor connects to; positive or negative. You can even install this resistor on the strip, but this will require an additional 1/4-inch length to accomodate it.

The Vector pins are placed into the 0.042 holes facing the same direction as the LED lens. Solder these pins on either the head side or the shaft side, or both sides, making the pin a part of the circuit. You even have enough space to wire-wrap and jump to another part of the circuit board, but it is best to keep the wrapping to only five turns. Mount the LED lens in the '\ellies' inch hole, push the LED into the lens until it clieds into place;

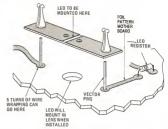


FIG. 4—HOW LED MOUNTING STRIP forms a plug-in connector when mated to suitable pins inserted into the PC board.

pass the LED leads through the holes in the mounting strip, making sure of the lead polarity; and push the strip down over the leads and the Vector pins until the strip fits snugly. To finish off, solder the LED leads to the mounting strip, and cut off the excess leads. You now have a removable LED from the lens that makes contact with the board circuit yet can be quickly replaced by another strip wita a mounted LED of another color, a brighter output, etc. This system also lets you mount the LED lens on a front panel, not directly on the printed circuit board. Drill a'v-inch hole in the PC board behind the front panel. The lens will then pass through the PC board, and by using the LED lens will then pass through the PC board, and by using the LED

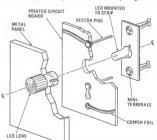


FIG. 5—LED LENS ON THE FRONT PANEL mates with the PC board and the LED on its mounting strip.

strips you can easily mount the removable LED's in the lens and show color through to the front panel. A front panel can now be serviced easily in case of trouble. Figure 5 shows the assembly.

Star No. two:

The No. K32 J-pin, marketed by Vector, is a perfect square wire used for wire-wrap connections or soldering into a printed circuit. It provides two points of contact, can be cut flush, bent at right angles, left as-is, can mount IC packages as if it were a socket, etc. (see Fig. 6).

To mount IC's directly without a socket, place J-pins one to each lead, and pass them through the mounting holes in the board; the pins will fit tightly against an IC lead in a 0.042 hole. The J-pin can face in either direction when it is installed next to the lead either up or down, depending where the lead will do the

most good for the circuit. Using the J-pin as a socket, you can remove the IC and place it back into the circuit if necessary.

A J-pin is used for terminal or tie points, in wire-wrap or PC systems and even in a rats' nest setup. This pin can be modified to take the place of many other hardware items, thereby saving

If you want a special IC socket, do the following: Take some Molex Soldercon IC pin connectors (another "star") and some J-pins; together they can be made into an IC socket of any pin size. Insert the Molex socket pins; push the J-pins next to the Molex lead: solder the Molex lead to the J-pin, top side and bottom; and you have a useful socket for wire-wrap circuits or

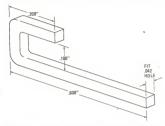


FIG. 6-THE VECTOR J-PIN is one of the more versatile of small hardware components, It's just over a half inch long.



FIG. 7-HOW MOLEX SOLDERCON AND VECTOR J-PIN can be united to form one terminal of a socket for an IC.

rats' nests. Figure 7 shows J-pin and Molex Soldercon units used together to make a socket point. Using a miniature tubular terminal and a J-pin in pairs on a printed circuit board results in a mounting point for any discrete component. You have set up a specialty socket for wire-wrap circuits for the large sevensegment displays, which are now easily removed or replaced into the circuits.

Have you ever designed a PC board and found you needed to add several more IC's not provided for in the original layout, but you lack the room to add them directly to the board? Set some J-pins into the circuit board, trying to take off the power connections and the input or output connections of the original circuit. Try to keep the J-pin pattern as square as possible. Take a second copper board, make it match up to the square, mark off the J-pin points where they will come in contact with the second board, drill 0.042 holes, and check out the pin alignment. If it looks OK, either use these holes to mount the second board directly or set up your miniterminals to have a removable second board in case the original board needs servicing. The second PC

board will mount the needed IC's to the first circuit. Be sure to allow additional space for other possible circuits. For added security provide for some 2-56 nut-and-bolt holes to hold the two boards together securely in place. Duplex circuit boards are very neat and take little effort to produce.

Want to try a right-angle connection instead of a duplex set-

up? If the original board has enough space for a second board mounted at a right angle, the J-pins can be modified to act as a push-in connector to the new board, which will have PC finger leads coming to the end of the board, similar to an edge connector (see Fig. 8.) If the original board has a blank area, you

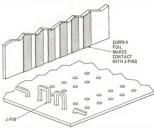


FIG. 8-HOW J-PINS CAN BE USED as edge-connector socket pins for a

can use a Ouik-Circuit IC pattern to set up the pins. Ouik-Circuits are copper foil, set up on a mounting strip with adhesive backing; they will stick securely to any clean portion of the board, have three holes for each contact point, and come in 36lead strips. Note if only one IC is added to the original board, use the Ouik-Circuit to make the connections.

If you decide to set up the right-angle second board to the first, then, using the Ouik-Circuit pattern for the necessary number of contact points, press the pattern to the first board. Drill out three holes per lead for each lead. Place the J-pins as shown in Fig. 8; this will take up two holes. Then make the circuit connections to the third hole to the original board. You now have the edge connector for the second board match up to its outer copper leads. Also be sure to securely mount the rightangle board, using nuts and bolts. You can even twist some wire tightly to the two boards, but it will have to be cut if you have to separate the boards.

J-pins can be used as edge connectors in a motherboard setup. It is a little time-consuming to use them up in this manner, but they can save quite a bit of money. If you have time plan your next motherboard using J-pins. Then Star No. Four is a third type of edge connector you can use for these motherboard setups.

Star No. three

Figure 7 shows how the standard-size Molex Soldercon can be made into a wire-wrap type of connector using J-pins. Here are some other modifications you may want to try out:

Want to mount something to the end of a PC board that would require some form of right-angle connector? Merely set up the holes in the PC board, insert the Molex sockets, solder them securely to the board, and bend them to a right angle to the board. You don't have to mount them in a vertical position only. You can also use these sockets as edge connectors. Put a Molex socket on one board, and matching J-pins on the second board bent parallel with the board after soldering. The result is two boards that can be connected and taken apart from the ends without having to purchase special hardware.

Now for the best use. To aidd a piggyback IC, that is to mount a second IC directly to the first one, you can now mount two IC packages in the space of one by using the following method: This setup works nicely with memory ICs, since most of the leads are common to others in nature, except for the data lines or enable line if two circuits are separated. Start by drilling the IC holes for the base IC unit; then drill a second row of holes parallel to the base IC but of the pattern and spacing). Now

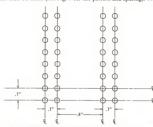


FIG. 9—THE STARTING POINT as you lay out PC board to take piggy-backed dual-in-line integrated circuits.

set up the printed circuit pattern to accommodate the common lines, the separate input and output data lines, and others needed for the two IC's. Figure 10 shows a pattern for a 2102 duplexmounted memory IC. After etching the circuit, mount the first memory IC by soldering directly to the board. Then take a piece

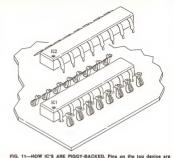
GROUND	00		0	0	AA }
+5 VDLTS	00		0	0	AA S
DATA IN NO. 1	-00		0	0	AA }
DATA OUT NO. 1 == DATA OUT NO. 2 == ENABLE NO. 1 (0)=	<u>-0</u>		0	0	AA }
EN ABLE NO. 2	₩ 6 @	PIF	0	0	AA }
AA		IMDN JUMP II		0	⇒ R/W NO.1 ⇒ R/W NO.2
AA	0 0	CDMMD	0	0	AA
AA	0 0		0	0	AA }
		NDTE: A	A = CD	MMDN ADD	RESS LINES

FIG. 10—HOW CONNECTIONS ARE MADE to the pins of piggy-backed IC's. Leads can be etched or Quik Circuit types.

of masking tape cut just to the lead size and place over the outside of the uncommon leads (data or enable lines). This is done to be sure no accidental connections will be made after the next step. Then insert a row of Molex Soldercons, solder in to all points of the copper foil, and bend the row as close as possible to the mounted IC in the board. The second IC, with its leads slightly bent outward, is then inserted into the Molex connectors and pushed firmly in (see Fig. 11).

Inspect for possible uncommon-lead shorting because these leads must be kept separate from each other. Common-fact shorting is OK as the circuit does this anyway. Just be sure of those leads requiring separate data information lines. It would be a good idea to paint these particular leads on the first IC after mounting it for additional protection and lead identification.

You now have two IC packages in the space of almost one. Consider also directly soldering a third IC to the uppermost IC mounted to the Molex pins. What a space saver this can be if you are hard pressed for room. If stackable IC sockets were



spreed outward and then inserted into the Molex socket.

available you could avoid this type of modification. However, as yet they are not on the market, or if they are, a darn good secret has been kept from us "home-brew" users and builders.

Star No. four

This is a simple way to drill all those precision-spaced holes in the PC boards: Using predrilled perforated board with 0.100×0.100 spacing, place some double-sided Scotch-brand tape onto the perforated board section you will use as a drill guide. Press the perforated board over the PC board area, mark the drill holes, and just drill them as straight as you can directly by using the guide, the motor tool and the right drill-bit size. Remove the guide and, using blade No.17 of an N-acto knife, you can easily remove any burst left by drilling the board. No need to use any clamps as the sticking action of the double-sided tape holds the guide securely when you are drilling.

Star No. five

Are you tired of buying expensive edge connectors and wiring them to the motherboard to provide a backplane circuit? Here is a better way: AP Products, Box 110-Q, Painesville, OH, and Robinson-Nugent, 800 E. Eighth St., New Albany, IN, make and market male and female headers, both straight and some right-angle male headers (the female headers are not right angle). Thes 36-connector-wide headers can be broken into lesser sizes if needed. They match up beautifully when properly mounted in the PC boards and provide continuity of circuits from one board to another, without separate use of cable and connectors.

To use these headers to make a backplane board, use a board (made by Vero Electronics) which has 36 lines running about 18 inches long. If the Vero board is used with the female headers, two additional holes will have to be drilled for each header installed into the board. Just insert the female header and solder in place all 36 tabs, or less if all 36 lines are not used. Use as many female headers in this backplane board as needed for the circuit cards that will be made using the right-angle male header to mate with the header on the motherboard. I use this system in place of the standard 22-pin edge connectors. All I do is set up the general pattern for the motherboard, consider how many individual cards will use this board, install the headers as I go and work on my individual cards with the idea of matching up the circuits to the backplane motherboard. I also provide additional space on the motherboard for possible revisions or additions. Figure 12 shows the headers set up to the Vero board and how the individual male-header cards are to be inserted so circuits on the card and motherboard are interconnected.

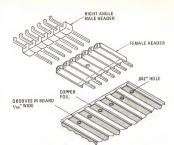


FIG. 12—HEADERS FORM CONNECTORS as auxiliary boards are plugged into the motherboard or main-frame.

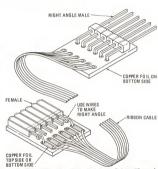


FIG. 13—RIBBON-CABLE CONNECTORS can be made from either male or female headers and ameli pieces of Veroboard.

Also I find I can make flat wire connectors with these headers. The female headers do require a slight modification, since they do not come with right-angle leads. Figure 13 demonstrates how to attach a female header at a right angle to a board using wires. All you need to build these cable assemblies is the Vero board (or equivalent); the necessary lines-8, 10, or up to 36; the flat ribbon cable; and male and female headers. Solder in the male or female header on one end of the strip, solder in the ribbon cable, and tape it securely; this completes one end of the cable assembly. Do the same at the opposite end of the wire cable or solder the wire directly to the circuit where it is to be attached. A matching male or female header will have to be provided in the circuit that has the cable connection attached to it. The foregoing method is an inexpensive way to use detachable cable assemblies in PC board layouts without buying special hardware. It is especially useful when you want to use cable between a main circuit board and a display panel.

Male and female headers can also be used as end board connectors, keeping in mind the right-angle modification for the females. The use for these headers is unlimited. Some readers who work with them will come up with other uses and modifications. From a simple motherboard and card connectors to cable

assembly, they can help to keep overall hardware costs down.

Star No. six

Vector's No. T-44 pins. Normal usage is to mount these pins in perforated board with a 0.042 hole, and use for mounting discrete components; the extra long lead can be wire-wrapped or soldered. Do you want to mount discrete devices to an IC socker! Consider this setup:

In the PC board install an LC socket or Molex pins. Then, take some perforated board with 0.100 × 0.100-hole spacing, cut it to fit the socket, and insert the T-44 pins where the IC leads would go. Now you can solder any device into the parallel pins, cut the T-44 pin lead to fit the socket snugly, and you have an inexpensive base to mount these discrete devices. A ready-made base for this purpose would cost a hundred times as much. Also you can modify the T-44 pin by cutting off the component mounting portion to make a T-pin (see Figs. 14 and 15). This modified T-44-pin to a T-pin can replace the Vector T-46 pin.

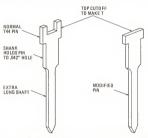


FIG. 14--MODIFIED T-44 PIN has notch section cut off forming a "T" pin aubstitute for the type T-46.

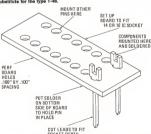


FIG. 15—VECTOR T-44 PINS AND PERFORATED BOARD can be used as a plug-in terminal strip for discrate componenta.

The T-section makes an excellent soldering base to hold the pin securely, and the extra long shaft length comes in handy.

A money-saving way to use IC test clips is to take the clip and carefully solder wires to each test terminal. After soldering and marking test lead No. 1, wrap up this end with electrical tape to strengthen the wire connections just made. Take a piece of perforated beard, put in the T-44 pins, match up the wires to the continued on page 121

TEST EQUIPMENT

All About Audio Oscillators

The audio oscillator of today ranges from the simplest audio source for signal tracing to the more precise and sophisticated lab-grade instruments. This story is about the latter type.

CHARLES M. GILMORE*

THE MODREN AUDIO OSCILLATOR ORIGInated when electronic products were simple. It has since developed into a complex instrument with sophisticated specifications. The electronics world it serves has increased in sophistication so much that the original audio oscillator would no longer suffice in the areas of design, service or research.

The audio oscillator's low-distortion, low-noise signals are mainly used in the design and service of high-quality audio equipment. These are by no means the only uses. Design, service and research measurements in frequency response, attenuation, amplifier and system gain, distortion, noise and impedance are all made possible or simplified by using high-precision audio oscillators.

In the literature on the history of lowfrequency signal sources, the terms "generator" and "oscillator" are used virtually interchangeably. A decade ago, these terms were truly interchangeable; generator or oscillator had little independent meaning. Today oscillator and generator indicate different technologies used to produce the fundamental signal. The term "oscillator" is applied to a circuit having a natural resonance and able to produce a pure sinusoidal signal. On the other hand, the term "generator" normally indicates some other form of electronic circuitry. For example, a constant-current source and a capacitor can be used to generate a triangle wave as the fundamental signal, and various electronic shaping networks process the triangle to produce the different waveforms.

A prime requirement for much audio work is a high-purity signal—a signal of extremely low harmonic content and low *Manager, Design Engineering, Heath Co., Bennoise. The oscillator is the logical circuit for a signal source meeting these needs.

Changes in the state of the art, especially in audio equipment, have resulted in a need for great improvements in audio oscillator specifications. Ten to fifteen years ago, the sine/square generator producing a sinusoidal signal with a 0.25% total harmonic distortion (THD) was entirely acceptable for audio equipment design and service. Today, to maintain increasingly sophisticated audio equipment, the audio oscillator must have THD specifications of less than 0.05%. and preferably less than 0.25%. This change has brought the audio oscillator to the forefront, and will soon make the sine/square generator obsolete.

Basic oscillators

Figure 1 is a block diagram of a typical audio oscillator. The major sections are: oscillator (the signal source), output amplifier and output attenuator. Occasionally, additional circuitry can be found to drive the oscillator to provide phaselocking or some form of frequency synchronization. Squarewave shaping circuits are used if squarewave output is also furnished, and meeting circuits are added to some audio oscillators to display output amplitude. Of course, all these instruments have some form of electronically regulated power supply: either battery or line, depending upon the application for which the instrument was designed.

Oscillator circuits

A number of basic oscillator circuits are used to generate fundamental signals. are used to generate fundamental signals. are used to generate fundamental signals. are used to generate fundamental signals in particular situations. The Wien bridge is one of the most used audio oscillator circuits. Figure 2-a is a simplified schematic of a Wien-bridge oscillator. The twin-T oscillator (Figure 2-b) is a variation of the Wien bridge and has other derivatives known as the bridged-T oscillator (Figs. 2-c and 2-d).

The Wien bridge and the bridged-T (capacitive) are usually continuously tuned by a variable capacitor, and ranges are changed by changes in resistance. The

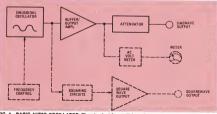


FIG. 1—BASIC AUDIO OSCILLATOR. The simplest type will include the sinusoidal wave generator, buffer amplifier and output attenuator. Other types may include meters, and squaring and electronic control circuits.

ton Harbor, MI.



bridged-T (resistive) is usually continnously tuned by varying one resistance (often by pushbuttons) and rangechanged with fixed capacitance values. The twin-T circuit is not often used for continuously variable oscillators, since three elements must be changed to change the frequency. Such oscillator circuits typically operate over the span of a few hertz to 10 MHz.

The Wien-bridge oscillator operates when the net phase shift of the two R-C (resistance-canacitance) combinations is zero. Therefore, a two-stage amplifier that provides a 360° phase shift is necessary for proper operation. Amplitude variations with changes in frequency are removed by a compensating element in one leg of the bridge. A thermistor, or more popularly, a tungsten lamp filament, is used for this amplitude compensation.

The phase-shift oscillator (Fig. 3) is another R-C circuit. Having approximately the same frequency range as the Wien-bridge oscillator series, the phaseshift oscillator derives its operation from successive 60° phase shifts at each of the R-C stages. This shift oscillator has two major disadvantages: The three R-C ele-

O OUTPUT

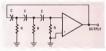


FIG. 3-PHASE-SHIFT OSCILLATOR, Each R-C section shifts the phase 60 degrees.

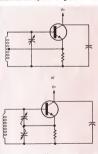


FIG. 4-COMMON L-C OSCILLATORS. a-Hartley circuit: b-Colpitts oscillator.

ments must be varied to change the frequency, and the oscillator output is amplitude-sensitive to the R-C ratio.

The frequency of both the phase-shift and Wien-bridge oscillators depends directly on the value of the capacitance. Therefore, a 10:1 change in the capacitance value produces a 10:1 change in the oscillator frequency. This characteristic of R-C oscillators makes them particularly popular.

FIG. 2—COMMON AUDIO OSCILLATORS. a—Wien-bridge oscillator; b—twin-T; c—bridged-T (resistor); d-bridged-T (cspscitor).

OUTPUT

continued on page 114 73

ic application of the month

XR-2208 Operational Multiplier

GENERAL DESCRIPTION

The XR-2208 operational multiplier combines a four-quadrant analog multiplier (or modulator), a high frequency buffer amplifier, and an operational amplifier in a monolithic circuit that is ideally suited for both analog computation and communications signal processing application. As shown in the functional block diagram, for maximum versatility the multiplier and operational amplifier sections are not internally connected. They can be interconnected, with a minimum number of external components, to perform arithmetic computation, such as multiplication, division, square root extent on components, to perform arithmetic computation, such as multiplication, division, square root extention. The operational amplifier can also function as a preamplifier for low-level input signals, or as a post detection amplifier for synchronous demodulator applications. For signal processing, the high frequency buffer amplifier output is available at pin 15. This multiplier/buffer amplifier combination extends the small signal 3-dB bandwidth to 8 MHz and the transconductance bandwidth to 100 MHz.

The XR-2208 operates over a wide range of supply voltages, ±4.5V to ±16V. Current and voltage levels are internally regulated to provide excellent power supply rejection and temperature stability. The XR-2208 operates over a 0°C to 75°C temperature range. The XR-2208M is specified for operation over the military temperature range of -55°C to +125°C.

FEATURES

Maximum Versatility

Independent Multiplier, Op-Amp, and Buffer Excellent Linearity (0.3% typ.)

Wide Bandwidth

3 dB B.W. - 8 MHz typ.

3° Phase Shift B.W. – 1.2 MHz typ.

Transconductance B.W. – 100 MHz typ. Simplified Offset Adjustments

Wide Supply Voltage Range (±4.5V to ±16V)

ABSOLUTE MAXIMUM RATINGS

Power Dissipation Ceramic Package

 Ceramic Package
 750 mW

 Derate above +25°C
 6 mW/°C

 Plastic Package
 625 mW

 Derate above +25°C
 5.0 mW/°C

APPLICATIONS

Analog Computation

Multiplication Division

Squaring Square Root

Signal Processing AM Generation

Frequency Doubling

Power Supply V+

Frequency Translation Synchronous AM Detection

Storage Temperature Range

Triangle-to-Sinewave Converter AGC Amplifier

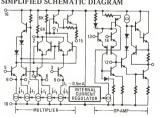
Phase Detector
Phase-Locked Loop (PLL)

Applications
Motor Speed Control
Precision PLL
Carrier Detection

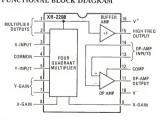
Carrier Detection Phase-Locked AM Demodulation

+18 Volts -18 Volts -65°C to +150°C

SIMPLIFIED SCHEMATIC DIAGRAM



FUNCTIONAL BLOCK DIAGRAM





EXAR INTEGRATED SYSTEM, INC. 750 Palomar Ave., P.O. Box 62229, Sunnyvale, CA 94088 (408) 732-7970 TWX 910-339-9233

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RADIO-ELECTRONICS

AVAILABLE TYPES

AVAILABLE	Temperature	
Part Number	Package	Range
XR-2208M	Ceramic	-55°C to +125°
XR-2208N	Ceramic	0°C to +75°
XR-2208P	Plastic	0°C to +75°
XR-2208CN	Ceramic	0°C to +75°
XR-2208CP	Plastic	0°C to +75°

DESCRIPTION OF CIRCUIT CONTROLS

MULTIPLIER INPUTS (PINS 3, 4, AND 5)

The X- and Y-inputs to the multiplier are applied to pins 3 and 3 respectively. The third input (pin 4) is common to both X- and Y-portions of the multiplier, and in most applications serves as a "reference" or ground terminal. The typical bias current at the multiplier inputs is $3 \mu \Lambda$ for the X- and Y-inputs and $6 \mu \Lambda$ for the "common" terminal. In circuit applications such as "synchronous AM detection" or "frequency doubling" where the same input signal is applied to both X- and Y-inputs, pin 4 can be used as the input terminal since it is common to both X- and Y-sections of the multiplier.

MULTIPLIER OUTPUTS (PINS 1 AND 2)

The differential output voltage, V_o , across these terminals is proportional to the linear product of voltages V_χ and V_y applied to the inputs. V_o can be expressed as:

$$V_o \approx \left(\frac{25}{R_x R_y}\right) \left(v_x v_y\right)$$

where all voltages are in volts and the resistors are in $k\Omega$. $R_{\rm X}$ and $R_{\rm y}$ are the gain control resistors for X- and Y-sections of the multiplier.

The common-mode DC potential at the multiplier outputs is approximately 3 volts below the positive supply. One of the multiplier outputs (pin 1) is internally connected to the unity-gain buffer amplifier input for high frequency applications.

In most analog computation operations, such as multiplication, division, etc., pins 1 and 2 are DC coupled to the op-amp inputs (pins 13 and 14). The final output, V₂, is then obtained from the op-amp output at pin 11, as shown in Fig. 2.

X AND Y GAIN ADJUST (PINS 6, 7, 8, AND 9)

The gains of the X- and Y-sections of the multiplier are inversely proportional to resistors $R_{\rm x}$ and $R_{\rm y}$ connected across the respective gain terminals. The multiplier conversion gain, $K_{\rm m}$, can be expressed as:

$$K_m \simeq \frac{25}{R_x R_v}$$
 (volts)⁻¹

where R_x and R_v are in $k\Omega$.

X- AND Y-OFFSET ADJUST (PINS 7 AND 8)

Two of the gain-control terminals, pins 7 and 8, are also used for adjusting X- and Y-offsets. Fig. 1 shows the typical adjustment circuitry which can be connected to these pins to null-out input offsets.

OP-AMP INPUTS (PINS 13 AND 14)

Pin 13 is the noninverting and pin 14 the inverting inputs

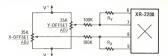


FIG. 1-OFFSET ADJUSTMENT

for the op-amp section. In most multiplier applications, these terminals are connected to the multiplier outputs (pins 1 and 2). Note: When the op-amp section is not used, these terminals should be grounded.

OP-AMP COMPENSATION (PIN 12)

The op-amp section can be compensated for unconditional stability with a 20 pF capacitor connected between pin 12 and pin 11. For op-amp voltage gains greater than unity, this compensation capacitance can be reduced to improve slew rate and small signal bandwidth.

OP-AMP OUTPUT (PIN 11)

This terminal serves as the output for the op-amp section. It is internally protected against accidental short circuit conditions, and can sink or source 10 mA of current into a resistive load. In most multiplier applications, pin 11 is the actual XR-2208 output, with the op-amp inputs being connected to the multiplier outputs.

BUFFER AMPLIFIER OUTPUT (PIN 15)

The buffer amp is internally connected to the multiplier section. The buffer amp has unity voltage gain, and provides a low-impedance output at pin 15 for the multiplier section. The buffer amp is particularly useful for high frequency operation since it minimizes the capacitive loading effects at the multiplier outputs.

The buffer amplifier is activated by connecting a load resistor, RI, from pin 15 to ground. When it is not used, pin 15 can be left open circuited. However, since the buffer amplifier output is a low-impedance point, reasonable care should be taken to avoid burnout due to accidental short circuits. The maximum DC current drawn from pin 15 should be limited to 10 mA. The DC voltage at pin 15 is typically 4.5 volts below V⁺.

APPLICATIONS INFORMATION

PART I: ARITHMETIC OPERATIONS

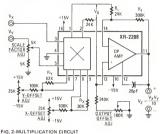
Multiplication

For most multiplication applications, the multiplier and op-amp sections are interconnected as shown in Fig. 3 to provide a single-ended analog output with a wide dynamic range. The circuit of Fig. 2 provides a linear output swing of 10V for maximum input signals of 10V, with a scale factor K = 0.1. The trimming procedure for the circuit is as follows:

- Apply OV to both inputs and adjust the output offset to OV using the output offset control.
- Apply 20V P-P at \$0 Hz to the X-input and OV to the Y-input. Trim the Y-offset adjust for minimum peakto-peak output.
- Apply 20V P-P to the Y-input and OV to the X-input.
 Trim the X-offset adjust for minimum peak-to-peak output.

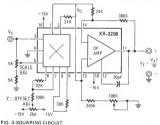
4. Repeat step 1.

5. Apply +10V to both inputs and adjust scale factor for $V_0 = +10V$. This step may be repeated with different amplitudes and polarities of input voltages to optimize accuracy over the entire range of input voltages, or over any specific portion of input voltage range.



Squaring Circuit

The recommended circuit connection for squaring applications is shown in Fig. 3. This circuit is the same as the



basic multiplier circuit with both inputs tied together, except only one input offset adjustment is necessary. Trimming procedure for the squaring circuit is as follows:

1. Apply 0 volts to the input and adjust the output offset to zero.

2. Apply 1.0V to the input and adjust the Y-offset until $V_0 = 0.10V$.

3. Apply 10V to the input and adjust the scale factor until $V_0 = +10V$

4. Apply -10V to the input and check that Vo = +10V. If not, repeat steps 1 through 3. Some compromise may be necessary in scale factor adjustments given in steps 3 and 4.

Dividing Circuit

Recommended circuit connection for performing analog division is shown in Fig. 4. This circuit uses the multiplier

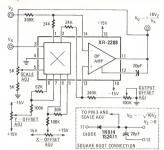


FIG. 4-DIVIDING CIRCUIT

in the feedback path of the op-amp. For the circuit shown. $V_0 = +10 V_z/V_x$ where $V_x < 0$ and V_z can have either sign. Positive values of Vx are not allowed, causing positive feedback and latchup.

This latchup mode is nondestructive to the XR-2208, and is common to all analog division circuits. The divide circuit is trimmed as follows:

1. Apply $V_z = 0$ and trim the output offset adjustment for constant output voltage as V, is varied from -1V

to -10V. 2. Keeping $V_z = 0$, and applying $V_x = -10V$, trim the

Y-offset adjust until Vo = 0. 3. Let $V_z = V_x$ and/or $V_z = -V_x$ and trim the X-offset

adjustment for constant output voltage as V, is varied from -1V to -10V. 4. Repeat steps 1 and 2 if step 3 required a large initial

adjustment.

Keeping V_z = V_x, adjust the scale factor trim for V_o = -10V as V_x is varied from -1V to -10V.

Square Root Circuit

This is essentially the dividing circuit with the X-input tied to the output. Thus, the voltage on the Z-input is divided by the output voltage, i.e. the output is proportional to the square root of the input. A diode is included in series with the output to prevent a latchup condition which would result if Vz were allowed to go negative. The square root circuit may be trimmed as a divider by disconnecting the X-input from the output, keeping $V_z > 0$ and $V_z < 0$. The square root circuit may also be trimmed in the closedloop mode by the following procedure:

1. Apply V_z = +0.10V and trim the output offset adjust for $V_0 = -0.316V$.

 Apply V₇ = +0.9V and trim the X-offset adjust for V₀ = -3.0V.

3. Apply V2 = +10V and trim the scale factor adjust for $V_0 = -10V$.

4. Repeat steps 1 through 3 until desired accuracy is achieved.

PART II: SIGNAL PROCESSING

AM GENERATION

Figure 5 is the recommended circuit connection for

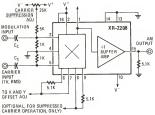


FIG. 5-AM GENERATION

Typical carrier suppression without offset adjustment is 40 dB for frequencies up to 1 MHz, and 30 dB for frequencies up to 10 MHz. For low frequency applications (f < 10 kHz), carrier suppression can be reduced to 60 dB by using the offset adjustment controls.

SYNCHRONOUS AM DETECTION

Figure 6 is a typical circuit connection for synchronous

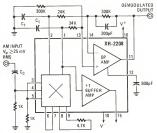


FIG. 6-SYNCHRONOUS AM DETECTOR

AM detection for carrier frequencies up to 100 MHz. The AM input signal is applied to the multiplier "common" terminal (pin 4). The Y-gain terminals are shorted, and this section of the multiplier serves as a "limiter" for input signals ≥ 50 mV RMS; the X-section of the multiplier operates in its linear mode. The low-pass filter capacitors, C1, at pins 1 and 2 are used to filter the carrier feedthrough. If desired, the op-amp section can be used as an audio pre-

amplifier to increase the demodulated output amplitude.

TRIANGLE-TO-SINEWAVE CONVERSION

A triangular input can be converted into a low distortion (THD <1%) sinusoidol output with the XR-2208. A recommended connection for this application is shown in Fig. 7.

The triangle input signal is applied to the X-input (pin 3). The multiplier section rounds off the peaks of this input and converts it to a low distortion sinewave. For the component values shown in Fig. 7, the recommended input signal level at pin 3 is ≈ 300 mV P-P in order to obtain a 2V P-P sinewave output at pin 15. This waveform can be further amplified using the op-amp section to provide high level (10V P-P), low distortion output at pin 11.

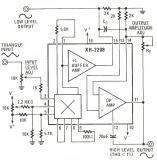


FIG. 7-TRIANGLE-TO-SINE CONVERTER

PHASE DETECTION

The multiplier section can be used as a phase detector. A recommended circuit connection is shown in Fig. 8. The

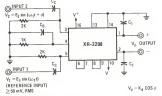


FIG. 8-PHASE-DETECTOR CIRCUIT

reference input is applied to pin 5, and the input signal whose phase is to be detected is applied to pin 3. The differential DC voltage, V₀, at the multiplier outputs (pins 1 and 2) is related to the phase difference, ϕ , between the two input signals, V₁ and V₂, as

$$V_{\phi} = K_{d} \cos \phi$$

where K_a is the phase detector conversion gain. For input signals ≥ 50 on W RMS, K_a is $\approx 2V/radian$ and is independent of signal amplitude. For lower input amplitudes, K_d decreases linearly with the decreasing input level. The capacitors C1 at pins 1 and 2 provide a low-pass filter with a time constant T1 = R1 C1, where R1 = 6 $k\Omega$ is the internal impedance level at these pins.

If needed, the phase conversion gain can be increased by using the op-amp section of the XR-2208 to further amplify the output voltage, V_ϕ . The XR-2208 operational multiplier is suitable for phase detection of input frequencies up to 100 MHz.

PART III: PHASE-LOCKED LOOP APPLICATION MOTOR SPEED CONTROL

A motor speed control where the frequency of the motor is "phase-locked" to the input reference frequency, f_r , is shown in Fig. 9. The multiplier section of the XR-2208 is

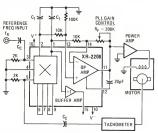


FIG. 9-MOTOR SPEED CONTROL CIRCUIT

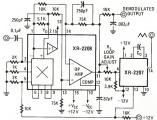
used as a phase comparator, comparing the phase of the tachometer output signal with the phase of the reference input. The resulting error voltage across pins 1 and 2 is low-pass filtered by capacitors Cl and amplified by the opamp section. This error signal is then applied to the motor field-winding to phase-lock the motor speed to the input reference frequency.

PRECISION PLL

A precision phase-locked loop may be constructed using an XR-2207 voltage controlled oscillator and an XR-2208. (See Fig. 10.) Due to the excellent temperature stability and wide sweep range of the XR-2207 this PLL circuit exhibits especially good stability of center frequency and wide lock range. In this application the XR-2208 serves as a phase comparator and level shifter. Resistor R₁ adjusts the loop gain of the PLL, thus varying the lock range. Tracking range may be writed from about 1.5:1 up to 12:1. For large values of R₁, temperature stability of center frequency is better than -30 pmm²C.

PHASE-LOCKED AM AND CARRIER DETECTION

The XR-2208 can be used as a "quadrature detector" in conjunction with monolithic PLL circuits to perform phase-



 $f_0 = 840 \text{ kHz}$ for $C_0 = 200 \text{pF}$ and RL = 1.6 KSWEEP RANGE = 120 kHz TO 1.4 MHz

FIG. 10-PRECISION PLL

locked AM demodulation and for carrier-level detection. Fig. 11 shows a recommended circuit connection for such applications. The XR-210 or XR-215 monolithic PLL circuits can be adjusted to lock on the desired input AM signal and regenerate the unmodulated carrier. This carrier frequency appears across the timing capacitor, CO, of the PLL and is used as the "reference input" to the XR-2208 multiplier. The AM signal is applied simultaneously to the PLL input and to the XR-2208 multiplier input (pin 3), as shown in Fig. 11.

The demodulated signal is then low-pass filtered by capacitor CI at the multiplier output, and can be amplified further to the desired audio level by using the op-amp section of the XR-2208.

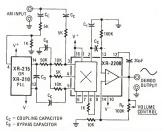


FIG. 11-PHASE-LOCKED AM DEMODULATION OR CARRIER DETECTION

In the carrier detector applications, the op-amp is used as a voltage comparator and produces a "high" or "low" level logic signal at the op-amp output when the input carrier level reaches a detection threshold level set by an external potentiometer. The output from the carrier detector can then be used to enable the "logic-output" stage of the XR-210 FSK modern.

The phase-locked AM or carrier detector system of Fig. 11 shows a high degree of frequency selectivity, as determined by the monolithic phase-locked-loop "capture" handwidth.

VTR Update



A look at the latest equipment introduced since our February 1978 videotape recorder roundup

FRED PETRAS

ONE OF THE PERILS OF DOING A "WRAPUP" or "roundup" type of feature article in the fast-moving world of home electronics is that by the time it appears in print it is outdated to some degree, Radio-Electronics has run into this situation again. this time with our feature on Home Video Tape Recorders (HVTR's) that appeared in the February 1978 issue. Even as the presses were rolling, a half-dozen changes had taken place, and by the time the issue hit the newsstands and the Post Office mailing circuit, a lot more had happened. This article, then, is meant as an update piece, to bring you as close to the whole story as possible within the framework of press deadlines.

New HVTR entries

As noted, several companies were poised to enter the HVTR market. And some have done so. Among them is Akai. which revealed it will market VHS decks (two- or four-hour not specified at presstime). Aiwa and Pioneer, both strong in audio tape recorders, have announced plans to sell Beta 2 units in the United States, Quasar, marketer of the VX-2000 system, is branching out to additionally market a VHS-4 unit priced at \$995. And Montgomery Ward has gone the VHS-4 route with a Panasonic-brand-name unit at \$995. (That price will be dropped to \$947 in its spring-summer catalog, according to trade reports.) Competitor mass-merchant J.C. Penney is going with an RCA-brand-name VHS-4 at \$1000.

Another company, not mentioned in our feature article, announced that it is entering the U.S. HVTR market this year. It is Shin-Nippon Electric Company, home electronics arm of Nippon Electric Company, Tokyo. The firm will market two-hour Beta models "sometime this year" under the NEC brand name. Initially, Shin-Nippon will offer Snoy-made units, but later will offer its own models. And, just as we finished writine the

And, just as we finished writing the above, word came that Philco is about to enter the HVTR field with a VHS-4 model in May.

At the same time we learned that

Magnavox is coming up with related HVTR products—25-inch color TV consoles with compartments to accommodate HVTR decks. A vertical armoire with Star tuning chassis is priced at \$1300; a horizontal console with Touch-Tune chassis at \$995; and a horizontal console with repulsar TV chassis at \$799.

As noted in our February article, HVTR pricing has been in a state of transition. Sony recently dropped its Beta 2 list price from \$1300 to a more comparitively viable \$1095\$, as did Toshiba, both on the heels of Zenith, which triggered the drops by cutting its price from \$1300 to \$995\$. (This move by Zenith was reportedly done to be competitive with RCA, Zenith's arch-enemy in the color TV field.) JVC came up with a price cut on its two-hour VHS from \$1280 to \$1050.

Thus, manufacturer pricing of the three main contenders—Beta-2, VHIS-2 and VHIS-4—is in the \$995 to \$1095 range. This \$1000 differential is usually smaller in terms of pricing at the retail level. With HVTR products still in a somewhat short-supply/heavy-demand state, retail pricing has stabilized to a notable degree. At the moment, no one is talking about or expecting any additional severe price cutting, either at the manufacturer level or at the retail level.

Relative to playing times, the battle continues. As noted, Sony, with two-hour capability, in an attempt to take the edge off the four-hour capability of competitors, came up with a "long-play" videotape that extends Beta running time to three hours, and a cassette changer to permit up to six hours of operation up to six hours of operation of the other hours of the other

This capability for long operation time poses a problem, namely, timers to enable its full use primarily in the area of automatic "absentee" recording. Manufacturers are reportedly at work on the matter and may possibly have LP timers in the marketplace by fall.

Heretofore, HVTR owners had three

basic, relatively low-priced color TV cameras to choose from—a JVC unit at \$1500, a GBC unit at \$1595 and a model from Toshiba at \$1700. Now Zenith is offering a two-tube Akai color camera at \$2895, and Sony is promoting a Trinicon color camera at \$2995.

A source at Akai said the company expects to offer a high-performance color model at a "breakthrough price" sometime this year. Meanwhile, other companies have spurred their research and development departments to devise low-er-priced color cameras for HVTR use. Among them is Sony, which recently entered a technical pact with NEC (Nippon Electric Company) with a view to develoning low-cost color cameras.

Videotapes

At presstime, Radio-Electronics was still hearing reports that blank video tapes have been in short supply in many parts of the country, namely in VHS form. The word from tape suppliers is that this situation will ease off shortly. Key manufacturers are stepping up their efforts on behalf of HVTR users by increasing production in some cases, or by adding new tapes production facilities. An example of the latter is Sony, which built a \$50 million tape plant in Alabama to assure adequate supplies of Betamax cassettes.

As predicted in our February article, creoxfed HVTR tapes are growing in abundance as more and more companies get into the field. The latest development is the formation of Video Club of America, Farmington Hills, MI 48024, which sells (via mail-order) two-hour movies from 20th Century Fox Studios at \$39.95, and longer features at \$59.95, in the major HVTR formats. The club also offers a trade-in program under which consumers who bought a \$39.95 video-tape can return it for a \$50 percent credit on their next purchase.

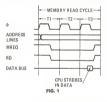
computer corner

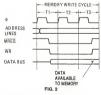
Z-80 How to interface the Z-80 to other devices and the associated timing WILLIAM BARDEN, JR.

LAST MONTH, WE LOOKED AT THE THREE different ways the $Z{\text -}80$ can be interrupted. This month, we'll take a look at how the $Z{\text -}80$ can be interfaced to other devices.

Before discussing some real-world examples of interfacing, we'll look more closely at the interface timing diagrams and interfacing signals involved. The Computer Corner in the December 1977 issue briefly discussed CPU timing for the operation code-fetch portion of instruction execution. The timing for a memory read or memory write is similar and except that the MI cycle (operation codefetch) is not active during the read or write memory operation.

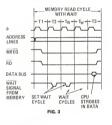
Figure 1 shows the timing diagram for a memory read and Fig. 2 shows the timing diagram for the memory write operation. They are usually three clock-





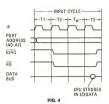
periods long, unless slow memories are being used, in which case additional wait clock cycles can be activated by the slow external memory. The MREQ signal is used to signal the external memory that a valid memory address is on address bus lines A0-A15. If a memory read is being performed, signal RD is brought down to a logic 0. If a memory write is being performed, RD is a logic 1 and signal WR is a logic 0. Data is strobed into the CPU register during read operations at the indicated time, or is available for a memory write during most of the three write cycles.

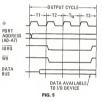
Provision is made in the Z-80 microprocessor for interfacing to slower memories by the WAIT signal down to a logic 0 informs the Z-80 CPU that external memory is not ready to transfer data. Figure 3 shows the result: It simply stretches the memory read or write time as long as required by slow memory.



I/O routines

Input and Output data transfers are initiated by unique I/O instructions. The CPU decodes these instructions and issues a special signal to indicate that data will be transferred to an I/O device. rather than a memory device. The Z-80 and the 8080 are different from most microprocessors in this respect since many microprocessors do not differentiate between memory addresses and I/O device addresses. Address decoding for many other microprocessors is done by the memory and I/O devices in a memorv-mapped I/O scheme. The net effect is that some of the address range of this type of microprocessor must be dedicated







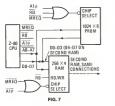
to I/O device addresses, rather than to memory addresses alone.

Figure 4 shows the Input and Fig. 5 shows the Output cycles on the Z-80. Note that the major difference is in the IORQ signal that notifies the external I/O device that a valid I/O device address is present on address bus lines A0 through A7. The RD and WR signals are used in the same sense as in memory read and write operations. Note that input and output cycles are four clock cycles long, because the CPU automatically inserts an additional wait cycle to provide more time for the I/O device to respond. The I/O devices can also use the wait state capability provided by the wait input to synchronize slow-speed I/O devices with CPU execution of Input or Output instructions.

Figure 6 shows the operation of a Z-80

CPU with a 1024-by-8 bit PROM. This simple example allows for no I/O device interfacing and is for demonstration purposes only. Address lines A0-A9 are brought into the PROM to provide 10 bits of address (0-1023). Since presumably no write operations to the PROM will be performed in the program, the signals RD and MREQ are OR'ed together to provide a chip select signal to the PROM. Signal RD is not really necessary since every memory access is a memory read.

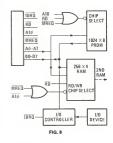
Figure 7 shows the same PROM stor-



age with additional RAM storage to supplement the somewhat limited RAM storage of the CPU registers in the first example. Here, it is assumed that the RAM will not contain a program, and that it will provide storage for program variables computed in the course of program execution. In addition, the PROM memory is located at addresses 0000 through 03FF (\$\phi\$ through 102310), while the RAM addresses are 0400 through 04FF (1024-127910). Address-line 10 can therefore be used to decode whether PROM or RAM is being addressed. While RD and WR must both be provided to the RAM memory, only RD is used for the PROM. As in the first example, RD is a redundant signal for the PROM since a MREO with address line A10 = 0 will guarantee that only the PROM is being addressed.

In Fig. 8, an I/O device is added to the system. Since only one I/O device is used, signal IORQ alone is sufficient to inform the I/O device that it is being addressed. A second simplification here is that the I/O device is a read-only device and that no decoding of read-versus-write is necessary. Anytime the I/O device is addressed, the IORQ line is brought to a logic 0, and the device will output eight bits of data on the data bus. No address decoding is necessary either, since only one I/O device is used in this type of configuration.

The above examples are simple, workable interfacing examples for memory and I/O devices. Additional address decoding would be necessary in larger configurations, in addition to further gating and buffering of Z-80 outputs and innuts



While the 8080 microprocessor and updates to the 8080, such as the 8085, remain extremely popular and usable microprocessors, the Z-80 offers many advantages over the 8080. The Z-80 appears to be the microprocessor of the future, as short-lived as the future is in the world of microprocessors. We will be watching for up-dates and will keep you advised. R-E

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Division of Eldon Ind , Inc Compton, CA 90220

hobby corner

A look at the various breadboarding and prototyping systems available (including a brand-new one) for building your own circuits from scratch. EARL "DOC" SAVAGE, K4SDS, HOBBY EDITOR

BACK IN THE OLD DAYS, THE HOBBYST HAN two choices of procedure when he wanted to design or test a circuit. He could tacksolder the parts together on a breadboard (literally, a pine plank), or hard-wire it right on the chassis and hope for the best. Even so, that wasn't too bad—all the components were large and few were fragile, so it was no great problem to put them in and take them out.

Later on, things got better. At one time I was fortunate enough to have a small Vector breadboarding outfit for tubes. It was quite revolutionary because it provided for temporary circuit building and a relatively easy change of components.

Today, a hobbyist without a modern broadboarding and prototyping system is at a great disadvantage. With subminiature (sometimes even microminiature) parts that are often sensitive to heat and/or physical handling, how can he work at all? He must throw a lot of time and a lot of parts.

Happily, that struggle is not necessary. There are some good breadboarding and prototyping systems available that are effective and efficient. They are time-saving, component-saving, temper-saving and money-saving. Best of all, they are not costly—in fact, you can start inexpensively, then add on when and if you have the need and the means.

Before taking a look at these systems, let's make sure we are talking about the same things. The terms breadboard, circuit board and prototype board have been used so much lately they have become quite confusing. Right or wrong, here's how we'll use them.

A breadboard is any device that allows circuit elements to be electrically connected and disconnected by applying pressure on the component leads. Usually, these temporary connections are made by using spring clips embedded beneath the surface of a perforated block

A prototype board allows circuit elements to be electrically connected in a physically stable manner. While components can be removed and exchanged, the connections are not considered temporary and are usually soldered or wire-wrapped. Furthermore, a prototype board accommodates a wide variety of circuits. One kind of board is called a universal printed-circuit (PC) board, as opposed to a dedicated PC board.

The term *circuit board* encompasses several types of boards—in fact, all boards *except* breadboards. Therefore, to avoid confusion, we will not use this term.

A dedicated PC board is one that has been designed for one particular circuit only, and cannot normally be used for any other. It can be constructed by attaching stick-on pads to a nonconducting board, by etching a copper-clad board or by grinding a copper-clad board or by grinding a copper-clad board.

First, we'll look at the characteristics of each of the major breadboarding systems and then, we'll do the same for prototyping systems. Next, we'll examine for some of these systems match for combination use, particularly a new system just being introduced in this country. Finally, we will suggest way to help you decide when and how to do what.

Breadboards

Table 1 shows five breadboarding systems along with the major characteristics of each. The prices indicated in the table and in this article are approximate suggested list prices.



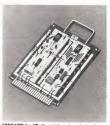
TIE-POINT BLOCKS by AP; one with an LED.



ALL-CIRCUIT EVALUATOR model ACE 236.

A breadboard is considered to be indexed if it is marked in such a way that each tie point can be identified by a number-letter (or any other) combination. (The full significance of indexing will become apparent later.) The wire size listed is not necessarily that claimed by the manufacturer but represents the maximum gauge that can be easily inserted into the tee points. Our breadboarding experience indicates that the maximum size of wire accepted is of greater significance than the minimum size.

The AP Products system features small Tie-Point Blocks that contain various tiepoint configurations, and there is one block that holds an LED. These blocks are available in packages of 20. In addition, the All-Circuit Evaluators, available in kit form or assembled, contain different groups of terminal and distribution strips mounted on a metal plate with binding posts and bumper feet (\$19-\$80). AP Products also manufactures Unicards. These are breadboard strips mounted on cards for modular card-rack construction (\$32-\$56). Also available are various special boards, a jumper wire kit (\$10), as well as connectors, sockets and ribbons for interboard connections



UNICARD by AP plugs into external circuitry.

The Continental Specialties braidboards interlock so that you can make bards interlock so that you can make larger layout with ease. Continental Specialties OT socious Protoboords on plates available as various Protoboords on plates with binding posts and feet (SI6–S80) and mounted on boxes with internal power supplies (SSS–S120). Useful accessories include a function generator (\$70) and an R~C bridge (S60).

Manufacturer	Hole Pattern	Size	In- dexed	Com- ponent Sockets Re- quired	Bus	Wire Size	Other	Name(s)
AP Products, Inc. Box 110-Q Painesville, OH 44077	Standard .1" × .1"	34 × 5TP* to 128 × 5 15 to \$19**	No	No	Attached and/or separate 12 × 4 to 36 × 4 \$2 to \$4**	to No. 20	Tie Point Blocks 1 × 4 to 4 × 4 and LED's 20 at \$4 to \$10	Terminal strips Distribution strips Unicards All-circuit evaluators
Continental Specialties Corp. Box 1942 New Haven, CT 06509	Standard .1" × .1"	14 × 5 to 118 × 5 \$3 to \$13**	Some mod- els	No	Attached and/or separate 12 × 5 to 40 × 4 \$2 to \$4**	to No. 20	See text	QT sockets & bus strips Experi- mentor Protoboards
E & L Instru- ments, Inc. 61 First Street. Derby, CT 06418	Standard .1" × .1"	16 × 5 to 128 × 5	No	No	Attached	to No. 22	See text	SK sockets Mini-board Universal breadbox
Saxton Products, Inc. 215 N. Rte. 303 Congers, NY 10920	3 special types, see text	3 × 5-in. modules 70 to 208 TP \$5 to \$20	Yes	Yes/No, see text	Attached	to No. 18	Detach- able con- trol panels	S-DeC T-DeC U-DeC
Vector Elec- tronic Co., Inc. 12460 Glad- stone Ave. Sylmar, CA	Standard .1" × .1"	8 × 4 to 24 × 4 (for mounting on .1" × .1"	Yes	No	Separate 1 × 4 to 1 × 8	to No. 20	Can use both sides, see text	Klip-Blok Klip-Strip Klip-Bus Patchboard

³⁴ units of five tie points each Approximete suggested list prices

board)

01242



CONTINENTAL SPECIALTIES 103 ProtoBoard.

The E & L Instruments system includes a Mini-board with binding posts and feet. Self-adhesive hook and loop fasteners hold the SK sockets and large components so that they can be mounted or removed with ease. The base of the Mini-board is somewhat more flexible



SERIES OT SOCKETS AND STRIPS by CSC.

than others we've seen. E & L also makes a Universal Breadbox consisting of SK sockets, binding posts and BNC connectors mounted on a sloping-top box. There's enough space inside the box to build such things as power supplies.



MINI-BOARD 101 by E & L Instruments.



E & L's model BB-IV Universal Breadbox

Vector and Saxon approach breadboarding somewhat differently. Let's consider the two systems in reverse alphabetical order since the Vector system is based upon .1 × .1-inch hole spacing. That spacing, by the way, conforms to the pin spacing of practically all IC's. This is why it is not necessary to use IC sockets with these systems.

The Vector system differs from the others in two significant respects: First, the .1 × .1-inch patterned tie-point blocks (called Klip-Blok's) are designed to be mounted on .1 × .1-inch perforated boards. The Klip-Blok's and Klip-Strip's can then be shifted around at will and placed in almost any position on the perforated Patchhoard

The second big difference in the Vector system is that the tie points are



VECTOR's Klip Strips and Bus Strips.



VECTOR 51X Klip-Blok DIP Patchboard.

constructed so that wires can be inserted from either side or even all the way through them. In fact, since the Klip-Blok's, Klip-Strips and Patchboard all have the same hole pattern, and since the Patchboard is mounted on an openbottom frame, components can be placed on both sides of the system. Although not necessary, of course, you have the option of using this system in this manner to continued on page 103

state of solid state

Delta modulation is finding many useful applications. A new integrated circuit from Motorola performs both the decode and encode functions. KARL SAVON, SEMICONDUCTOR EDITOR

TRANSMITTING DIGITAL DATA OVER RAdio, telegraph or telephone channels is
one of the most reliable methods of
communication. Analog signals, whether
audio, video or control waveforms, can be
transmitted with similar reliability if
they are first digitized into binary equivalents. If the instantaneous analog levels
are first converted into a binary series of
ones and zeros, they can then be routed
through a digital communication channel
and then decoded or reassembled into the
original waveform.

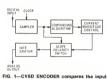
Binary transmission is inherently reliable because it is simple to distinguish between only two different levels. The two levels can be represented by two DC voltages, two frequencies, two phases, or other more complicated schemes.

Motorola Semiconductors has developed the XC3417 and XC3418 IC's to perform the modulation and demodulation functions of a CVSD (Continuously Variable Slope Delta) modulation scheme.

Delta modulation, developed about 30 years ago, approximates an analog signal by using line segments. It is a digital coding system that performs well considering it requires relatively few components. The system is asynchronous and, therefore, does not require the transmission of sync signals. Delta modulation is somewhat less efficient in bandwidth than pulse-code-modulation (PCM) for speech and video. However, its characteristics are just about right for telephone-quality speech. For many telemetry and control applications, delta modulation uses less bandwidth than PCM.

How it works

Figure 1 shows the block diagram of a CVSD encoder. The analog input signal is compared against a waveform that is approximately the same as the one that all eventually be decoded at the receiver. Based on the result of this comparison, the system then reduces the error between the two comparator inputs. At specific clock-cycle intervals, the comparator output is sampled to determine the direction and magnitude of the slope of the next segment of the approximated waveform.



signal against a waveform that is approximately the same as the decoded signal and reduces the error between them.

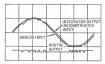


FIG. 2-WAVEFORMS showing how the CVSD encoder tracks the analog input.

Figure 2 shows that when the approximated signal exceeds the input wave-form, the comparator changes the polarity of the slope. The sampler output operates the slope polarity switch, which directs current into an integrating capacitor. Since the integrated voltage is too great in this case, the current is switched so that the output discharges towards a lower voltage.

At each comparison interval, if the approximated signal still exceeds the input, the negative slope is maintained; or if the approximated signal is less than the input, the slope is switched to a positive value.

Some modified delta-modulation systems use a resistor to discharge the integration capacitor at a relatively high rate. This modification further simplifies the circuit but increases the channel bandwidth.

The digital output of the system, the same output that is transmitted over the communication channel, is the input to the slope polarity switch. By transmitting the slope polarity of the approximated signal, an integrator in the decoder, similar to the one used in the encoder, recon-

structs the same approximated signal. Approximate filtering smoothes out the discontinuities to produce a close copy of the original analog input.

The companding algorithm and current-magnitude control blocks in Fig. 1 make the system even more interesting and useful. To optimize system performance, the integrator-output slope is changed to compensate for the range of input-signal slope variations. Constant-slope line segments may be too shallow to follow, or so steep that they overshoot the input waveform.

An algorithm to solve this problem was developed that was easy to implement in the circuit. A shift register keeps track of the slope polarity for a fixed number of clock pulses, if the slope polarity does not change for a number of clock pulses, it is possible that the output waveform is not keeping up. Under these conditions the slope is increased or decreased, accounting for the term, "continuously variable."

Figure 3 shows that the decoder has circuit blocks in common with the encoder. In fact, it is possible to switch a

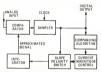


FIG. 3—CVSD DECODER contains the sam functional blocks as the encoder.

couple of leads around on the IC to change the circuit from an encoder to a decoder. You can do this in simplex operation when only one station transmits at a time. Wherever full-duplex operation is required (simultaneous transmission and reception), separate modulators and demodulators are needed.

Figure 4 shows the schematic of a simplex voice CVSD using the XC3417 integrated circuit; all the functions discussed are included on the single IC.

The encode function is enabled by closing the push-to-talk switch, transferring the solid-state encode/decode switch to its upper encode position.

The analog input is shown AC-coupled to the inverting comparator input. The other input to the comparator is the reconstructed waveform reproduced at the receiver's demodulator. The comparator output continuously shows whether the input waveform is lower or higher than the reconstructed waveform.

The comparator output feeds the serial input of a three-stage shift register. Clocked by a 16-kHz signal, the shift register reads the comparator output on the falling edge of each pulse. The output of the first shift-register stage is the sampled output of the comparator and becomes the digital output.

The slope polarity switch sets the direction of the current that feeds integrator network R6-C2. The current integrated by capacitor C2 is equal to the voltage across Rx divided by the resistance of Ry (13K), Because the resistor connects to high-input impedance opamp A2, essentially all the current in Rx flows into the polarity switch and then into integrator network R6-C2. The opamp forces the voltage of the inverting and noninverting inputs to be equal. Controlling the voltage on pin 3 controls the voltage on pin 4 and also the value of the integrator current. Filter capacitor Cs is connected between pin 3 and Vcc, and Rs

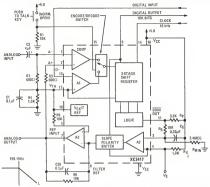


FIG. 4—SIMPLEX VOICE CVSD built around the XC3417. Encode and decode functions are controlled by the push-to-talk switch.

couples the inverted coincidence output to pin 3.

A logic circuit connected to the parallel outputs of the three shift-register stages detects when the three outputs are either all ones or all zeros. If the output-signal polarity has been equal for three consecucontinued on page 98



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EVER SINCE TV BEGAN, WE HAVE SEEN one very familiar symptom: "Thin horizontal line across screen." This cause is easy: there's no vertical sweep. The problem is usually quite simple to find and fix. With the advent of solid-state TV, a new one has turned up: "Thin vertical line on screen." This shakes up us old tube-type technicians! I do not remember ever seeing this on a tube set-that is, for more than a few milliseconds when the damper blew up or something similar. This is because any problems in the horizontal deflection voke killed the boost, which, in turn, killed the sweep, high voltage and the whole works in one fell swoop.

Most of the solid-state sets have an entirely different basic circuit. The horizontal deflection coil and the flyback are in shunt across the horizontal output transistor. If the horizontal deflection coil opens, the high voltage is often unaffected. There are also other differences in the deflection voke circuitry as compared with the tube sets. Let's see how a couple of solid-state deflection circuits work, so that you'll know what to look for if this kind of symptom occurs.

Figure 1 shows a basic circuit, stripped to its bare essentials. The horizontal output transistor provides a current pulse that is fed to the flyback (which works just like other flybacks). This signal is also fed into the horizontal deflection coils, which are in parallel with the flyback. The current pulse flows through the voke windings, then returns to ground through a voke-return capacitor. The pulse actually charges and discharges this capacitor, thus completing the AC circuit for the horizontal deflection coils

HDRIZDNTAL HDRIZDNTAL TRANSISTOR DEFLECTION COILS -000-000-YDKE-RETURN CAPACITOR TRANSFORMER Fig. 1

What happens if this capacitor opens? A thin vertical line. There is a dandy quick check for this, just scope the vokereturn capacitor. If the yoke-drive pulse

JACK DARR, SERVICE EDITOR appears on the hot side but there is obviously no horizontal sweep, there's your

answer. Tack another capacitor across the original (with the power off) and check. In actual sets, the circuits include a lot more components than the one in Fig. 1.

The complete horizontal-deflectioncoil circuit for one popular chassis is shown in Fig. 2. Let's follow the signal through the circuit starting at the collect-

or of Q401. The signal goes to the flyback and also to the deflection voke socket.

deflection and pincushion board. All test points are easily accessible in this chassis, and capacitor C405 is right out in the open! In any other chassis, you might not be this lucky, but the troubleshooting principles will still be the same.

In another set, the circuit is basically similar. But instead of returning to DC ground, the horizontal deflection yoke returns to a horizontal-centering control with a pair of diodes. The horizontalcentering control is connected to the +145-volt line. However, it seems as though the AC return path is made at this point through a 30-µF electrolytic capac-

HDRIZDNTAL DITTPIT +127 8V 00000 ► REG +121V PART DE FLYBACK 60 HDRIZ DEFL COILS DAMPING 14 C405 0.1Ω 0.1Ω 0.03Ω 0.03Ω 0401 ¥ L405 000 - 000 000 - 000 T403 PIN TRANS PIN TRANS

J104 pin 5. From here it proceeds through the paralleled horizontal voke windings (others are in series; it makes no difference) through the primary windings of T402 and T403 and two pincushion transformers. From T402, the signal goes through C405, a 0.55-µF capacitor (there's the voke-return capacitor: I knew we'd find it in here somewhere!); and on through L405 to ground.

This complete path for the horizontal deflection voke currents is easy to check out with an ohmmeter. Start with one ohmmeter lead on pin 6 of the deflection yoke socket (J104). (You did check the yoke? Good.) You can check both pin transformers by reading the resistance from J104 pin 6 to the top of capacitor C405. Both of these windings measure only 0.26 ohm total. From the bottom end of C405, the other pin transformer measures only 0.3 ohm. If there is continuity at these points and still no horizontal sweep, the capacitor is apt to be onen.

In a case at point, a Service Clinic reader wrote that he had no horizontal sweep in an RCA CTC-71J. I recommended checking the points as described above, and he found an open conductor on the PC board on the PW400 horizontal itor that's connected to ground on the centering control. The + 145-volt source in the DC power supply had better be at AC ground if the filter capacitors aren't open! This small difference in the circuit won't affect the basic diagnosis, of course.

So, if this symptom appears in a solidstate TV set, you can immediately eliminate a couple of things; namely the horizontal output stage, flyback, low voltage DC power supplies, and high-voltage rectifier. Also, you know the drive pulses are present or the other stages wouldn't be working either. If you follow the horizontal deflection coil circuit from the output transistor all the way to ground, the faulty part should show up pretty fast.

As I said, this can't happen in tube TV sets. I have never seen a genuine case like it. However, once I thought I did on an Admiral chassis that was brought in for service. Like most of the sets manufactured in those days, it had a large flat pantype chassis with the picture tube strapped to it. I set it up on the bench, with the picture tube on top, and applied power. Lo and behold, a thin vertical line did show up on the screen! I tested the horizontal sweep circuits, but this showed absolutely nothing wrong. There was plenty of high voltage, the drive wave-forms were all fine, etc. After some head scratching, the reason finally dawned on me. This was one of the rare sets with the chassis mounted vertically on the side of the cabinets of batt the picture tube was not on the top but on the side! Placing the tube in this position made it look better, now I had a thin horizontal line. I fixed the problem in the vertical sweep, and took it home (blushing a little, but happy). The moral of this story is: "Don't get too much exercise by jumping to conclusions!" Make a complete analysis first.

protective diode to the common ground or a wiring short in the input to the heater circuit. The trouble is not likely to be in the middle of the line, or some of the tubes would light very brightly.

"PUMPING" SPEAKERS

Hare's a funny one: I've got a Harman-Kardon 330 receiver that has a very lowfrequency pulsation, and the pilot light dims if the speakers are connected. After much searching, I found that this can be stopped by disconnecting the left preamp. The DC voltages at the preamp outputs are different. What have I overlooked?—D. S., San Jose, CA. I think you've found it. Something in that left preamplifier is causing a feedback to make the speakers "pump" and take excessive current. Disconnect both preamplifiers and feed a signal into the power amplifiers, see if their output signals are equal. If so, connect the righthand preamplifier, and feed a signal into it. If this works, take that left preamplifier apart and you'll find something in there that's way off.

SCREEN BLACKOUT

This problem on an RCA CTC-35 has me stumped! The screen goes dark, but it continued on page 92

service questions

MULTIPROBLEM TV

This is a tale of a tough dog—a Muntz AS-9015. This set had: a dim picture, poor focus, vertical shrinking. I checked the focus voltage; it didn't read right. Then I recalibrated the high-voltage probe, and now had 6 kV so that wasn't it! Checked the voltage-dependent resistor in the vertical circuit. The vertical-input grid resistor and the 150K resistor in the height-control circuit were off-value; changed them, but no help. Round and around!

Finally, I read the + 1050 boost-boost voltage: I'd replaced the boost rectifier first—ZERO. I replaced it again ... WHAM-O! Bright, I'ull picture, no focus problem. The boost rectifier I used the first time around wasn't marked, and I guess I managed to get it in backward! (I've also run across some top hat diodes with markings reversed, so check these before installation.) Thank you for the help in solving this dog.

(Actually, about all I gave him was sympathy. Thanks to George Welker, George's TV, Spokane, WA, for this tale of woe.)

CROWBAR SHORT

I've really got a dead short in a Zenith 12CB12X. The fuse blows so fast that I can't find it! I've checked everything and found nothing. I'm pulling my hair out.— L. A., Franklin Furnace, OH.

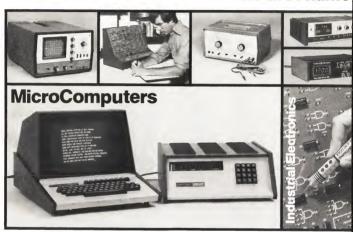
Don't do that . . . when you get to my age, you'll need it!

age, you have two loads on the AC interior one is the heater circuit, the other, the DC power supply. You say that a slow-blow fuse makes the heater rectifier blow out. This is a clue. Disconnect the heater rectifier and then turn it on, connecting a '25- to 50-watt lamp across the fuse holder. If the lamp lights up, there's a short in the DC power supply (diode, input-filter capacitor, etc.). If the lamp doesn't light up, the short is in the heater circuit. The likely suspects are: the



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SERVICE QUESTIONS

continued from page 87

does so only once every three or four weeks. When it does, the high voltage is still up. Then. I can turn it off for five minutes, turn it back on and it works for three to four weeks more. Something is biasing-off the picture tube, right?-R. D., Springfield, VA.

Right. There are a couple of things that cause this. One is a bad heater contact on the 12BY7 video output tube socket. If the heater contact is bad, this kills the tube, there's no plate current, the plate voltage rises to +405 supply voltage and out goes the screen. Similarly, it could also happen with the jumper on the PC board in the heater circuit to the two difference-amplifier tubes; if there's a bad solder joint here, these tubes go out and their plate voltage goes up, biasing the tube to heavy conduction and out goes the screen. It's more likely to be the video output tube in this case, since the difference amplifiers cause the high voltage to pull down just a little or, in some cases, a

HIGH-VOLTAGE SHUTDOWN

I had a Ouasar TS-938 with a peculiar symptom: If it was turned on in the evening, nothing came on, However, if it was turned on in the morning, it would play all day until turned off at night.

You gave me some hints from the Quasar Field Engineers, and they worked. When I reset the DC voltage to get +100 volts on pin 16 of the JA panel. everything worked fine. I didn't know that some of these voltage controls would shut down on low line voltage! When they write "sealed at the factory" on that highvoltage adjust control, they aren't kidding. The stuff they use could seal safes!

(Thanks to George Senn, Red Bank, NJ, for this feedback. Here's another way of resetting that voltage control: Ouasar says to remove the original control, replace it, adjust it and then reseal it. A lot easier than trying to get that cement off!)

DEFLECTION YOKE

I need some help in getting a new deflection yoke for a Bradford TV, model WTG-61059. The original part number is 490V017C01. Do you have the company's address?-F. C., Victory, NY.

Sorry, Bradford isn't with us any more. However, here's one good clue: That part number is obviously a Westinghouse part number. Westinghouse is one of 15 firms that built Bradfords that are listed in my J. W. Miller Company Catalog No. 175. With a little head scratching and a lot of cross-checking, I found a substitute listed for this voke; a Triad YT-103-1.

NO BRIGHTNESS CONTROL

There's a brightness problem in this Sharp C-922 that I can't find. The raster is

continued on page 94

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too bright, there are retrace lines, etc., and the brightness control has no effect. I found +58 voits on the common control grids of the picture tube. This should be only -1.5 voit. When I shuth this to ground with a resistor to give zero voits, the brightness control works Where does this small negative voitage come from?—E.F. Battimors, MD.

The picture-tube grid circuit is a bit complicated. Apparently the bottom end of the high-voltage multiplier goes to the grids and then (somehow) to ground, possibly through the DC power supply.

This is some kind of beam-current control circuit. The small amount of voltage that is developed from the highvoltage multiplier return would be positive. However, there's a diode in the
circuit marked "Isolation" this current
flows in pulses that may develop enough
negative voltage to cancel the positive voltage fed through those resistors. Since
the problem seems to be somewhere in
this area, check all resistors and the
diode.

HIGH-VOLTAGE SHUTDOWN
I need an idea on this Magnavox T989-



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01. The h	igh-voltage shutdown works too
fast. If I	unhook the reference voltage,
	g the shutdown, everything
	rfectly. The high-voltage is 29.5-
	+ 120-volt line regulates nicely,
and so o	n. However, when I rehook the
reference	voltage, it works for quite a
while, th	en away it goes again!-C. F.,
Inla KC	

to lost, 828. Since the high voltage and everything else seem to be normal, I agree that the problem is in the high-voltage shutdown. I looked through my Magnavox file and found a Service Note on "Nuissince Tripping of High-Voltage Shutdown"! The note says: Try setting the high-voltage to 280 clear up the problem of the little shutdown and the same than the state of the same that the same than the same th

OPEN CEILING HEATER WIRING

Lloyd F. Bazant, Design Engineer with Western Instruments, 4714 S. W. Willetta St., Albamy, OR 97321, writes that his company makes a special "locator" device for finding open circuits in built-in ceiling heating wires. [A reader in Rossville, GA, wrote (Radio-Electronics, November, 1977) asking about the subject.] Oddly enough, this instrument is called a "Ceil-Heat Fault-Finder," which is exactly what it does. Thanks for the data.

FAULTY REMOTE CONTROL

I have a problem in the remote control of a Philco 13.142 chassis. I can make it work on the channel selector or on the volume control, but they won'l work together. It's either one or the other. What's happening?—M. B., Las Vegas, NV.

This sounds very much as if you have an alignment problem in the receiver. You have two under transformers on the limiter output. The 38-kHz transformer is the channel selector. Align each of these transformers and make sure the adjustment shows a definite peak. It is possible one of the ringer bars in the transmitter is broken, or something is damping it and throwing it off-frequency. Use the alignment procedure in Sams Photofact 650-24 that covers this receiver.

VIDEO PROBLEM

Recently, I wrote you for ideas on an AC problem in the video of this Zenith 814836. I got the schematic after I wrote you. As soon as I saw the schematic, I knew what was wrong. I had eplaced a diode in the 24-volt source. This diode turned out to be 2 Zener and I had used an ordinary diode that wasn't well marked to replace the Zener. That cleared up the problem.—C. C., Chicago, It.

Good!

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continued on page 96

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SERVICE OUESTIONS

continued from page 94

LOSS OF WIDTH

I can't get enough width on this Philco 180785A. It's shrunk in ebout 2 inches on each side of the screen. The high voltage is low too; it drops to about 14 kV II I turn up the brightness, and the rester blurs. The low brightness is about 22 kV. I've checked and changed a lot of things end can't find it.—M. D., Willimantic, CT.

Step one: Read the control grid voltage on the 6KD6 horizontal-output tube. The normal reading is ~57 volts. If this reading is quite a bit more negative than it should be, try a new VDR. This resistor is the one that's used in the 6KD6 control grid and return circuit. It's apparently the only high-voltage regulation used in this chassis. If this resistor is bad it can develop to much negative bias and reduce the output of the 6KD6. Note that both sweep and high voltage are down. Just for luck, check the boost voltage. If this is low, you'll have these symptoms.

SYNC-AGC PROBLEMS

I'm having an odd problem in this CTC-36H RCA. When it's turned on, the horizontal sync goes. Then, the whole picture starts to fade after about 15 seconds, starting from the corners and working to the middled inside of 10 minutes, it ooes "click," and then works perfectly! Whet's the matter with this thing?—K. B., Brooklyn Park, MN.

There is one part that can, and does, cause weird symptoms like this—an in-termittently open filter capacitor! If this capacitor is open or away down in capacitance at turn-on, it can cause a feedback signal through the B+ line that can give you almost any kind of symptom you want. Then, when the chassis has warmed up enough, the open joint heals, the set returns to normal and you sit there wondering what happened.

Clue: Atturn-on, scope the B+voltage lines, especially around the horizontal oscillator and/or the AGC stages. Look especially for pulses at horizontal frequency. If you see these pulses, that's probably what it is.

TRANSIENT SPIKES

You answered a reader's question in the July 1977 issue, saying that his trouble could be transients in the car's electrical system. I agreel I'm a Motoral wo-way radio technician and the Motorola service bulletins state that in many cases, solenoids (and similar devices) in cars can cause spike transients of up to 400 volts peak when de-energized.

All Motorola's new equipment uses a dual Zener diode across the 12-volt input—i.e., 25-volt Zeners back to back. 1

have seen these transient pulses hit hard enough to blow the diodes completely. The idea is to shunt off any pulse above 25 volts, and it does.

Thanks to Brian S. Hansen of Killingworth, CT for this information

NO HORIZONTAL SWEEP

This RCA CTC-71J chassis has only e vertical line down the center of the screen. I've checked and changed the yoke; still no horizontal sweep. There's no yoke-return capacitor that I cen see. Any helo?—J. R. Detroit MI.

I think you've done what I just finished doing—getting lost in that horizontal-yoke return circuit! The brown wire from the horizontal yoke is the return, and it goes all around the harm (through the pincushion circuitry), but it does go through a 0.55-µF yoke-return capacitor C405. Capacitor C405 is not the tight-hand side of the PW400 beard, just below the toroid transformer. The capacitor is easy to get at, after you find it. Check all the connections and continuity through the pin circuits, as well as the capacitor.

WEAK COLOR

There's a color problem in this Admiral 4H12 chassis. The color signal is weak, and everything is all right up to the 6LE8 demodulator input, as far as the color signals are concerned. The colors ere ell

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normal, they're just low in amplitude. Is there anything in your notes on this?— R. C., Pacoima, CA.

We have found problems in sets using high-level demodulators, with tubes similar to the 6LE8 and others. The key clue is in the plate voltages; if these voltages are off, try a new tube. We've fixed several sets having this problem, using a new tube. Try a new 6GH8 in the 5.8-MHz oscillator socket just for luck. A low oscillator signal can also cause weak color.

HIGH-VOLTAGE DROP

I have no high voltage on a Webcor 4012 TV. (All parts are made by Toshiba, If I unhook capacitor C411 from the flyback, I can read +250 volts on all its terminals. When C411 is connected, this voltage drops to less than +100. I hope you can help.—F. C., Seminole, FL.

So do I. Capacitor C411 is the boost capacior, and the symptoms indicate it is very leaky. Note that your B+ voltage should be only-135, and you are reading +250 volts with the capacitor unthooked. Therefore, you are receiving a tiltude boosts' from stray capacitance. Substitute a new capacitor for C411 (which is marked only for 400 volts). Try using at least a 600-volt capacitor here. The normal boost should be +350 volts. ReE



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continued from page 85

tive clock edges, pin 11 switches low. Since one end of Cs is returned to the Vcc supply, the capacitor charges toward Vcc during periods of no coincidence. The voltage across the capacitor increases as does the voltage on pin 4 and the integrator current. This is how the companding algorithm is used to correct for insufficient or excessive slope. Time constants of the coincidence filter (also known as syllabic filter) are selected between 6 and 50 ms. In this particular application, it is equal to $(R_p + R_c) \times C_c$ = 7 ms.

For decoding, the push-to-talk switch is released so that the analog switch drops to its lower position and the shift register is fed from the digital sense amplifier instead of the modulator comparator Other than that, everything works exactly as before. The same integrator circuitry and coincidence companding algorithm insure that the reconstructed signal is similar to the one approximated at the transmitter. Low-pass filtering removes the quantizing noise.

To design the circuit shown in Fig. 4

around the XC3417 or XC3418 integrated circuit, values must be assigned to a number of components to optimize the signal-to-noise ratio and distortion As with all communication channels, handwidth and amplitude limits require using filters and clock rates that are consistent with the limitations of the particular medium being used

In conventional delta modulation systems, the clock rate is normally selected to be greater than the highest frequency to be sampled. Limited-integration delta modulation systems approach pulse-rate modulation (PRM) when the integration time actually becomes smaller than the period of the lowest signal frequency. Clock frequencies in the range of 9.6 to 64 kHz can be used to drive the circuit shown in Fig. 4. The higher the clock rate the greater the handwidth needed for the channel, and the greater the signal-tonoise ratio. Voice channels are limited to a 9.600-Hz clock frequency, some radio systems can reach 12 kHz, and commercial telephone circuits will handle 37.7 kHz. Clock rates above 15 kHz work better with a longer shift register, which is how the four-bit XC3418 differs from the three-bit XC3417.

The value of Rx is selected so that the system can follow the input signal with companding ratios (the time the coincidence circuit is activated) that do not exceed about 25%.

With no analog input to the system, the digital output is an alternating sequence of ones and zeros. Although certain modified delta systems benefit from nonsymmetrical one-zero patterns, the one shown in Fig. 4 is designed for perfect balance. Because of circuit imperfections, the alternating ones and zeros should have a minimum step size of 20 mV (at 16 kHz) to guarantee the proper idle channel condition. The value of Rmin determines the idle channel step size.

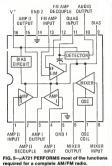
The XC3417 and XC3418 integrated circuits are available in ceramic or plastic 16-pin dual-in-line packages. The logic and analog functions are implemented with a combined 12L/Linear Bipolar processing technology. A data sheet is available from Motorola Semiconductor Products, Inc., Box 20912, Phoenix, AZ 85036.

AM/FM radio circuit

One of the primary design motivations for the Fairchild µA721 IC was the severe space limitations in automobile AM/FM radio/CB transceiver combinations. This IC along with a two- or threetransistor FM front end, a couple of diodes, some tuned circuits and an audiooutput stage makes a complete AM/FM radio.

Figure 5 shows the AM/FM radio 1C, which includes a bias circuit, two amplifiers, an IF limiter and detector and an oscillator mixer.





For additional details, write to Fairchild Camera and Instrument Corporation, 464 Ellis Street, Mountain View, CA 94042

Another radio circuit

SGS-ATES Semiconductor Corp. also has AM/FM integrated circuits-the TDA1220 and TDA1230. The TDA1220 has an FM IF amplifier-limiter, an FM detector, and an AM RF amplifier, mixer, oscillator, IF amplifier and detector. The FM limiting sensitivity is 30 µV, the amplitude modulation rejection (AMR) is 50 dB and the S/N ratio is better than 60 dB

The TDA1230 goes further with an AF power amplifier that is driven from the on-ehip FM detector or from an external audio source.

Voltage regulator

Silicon General's SG1532, SG2532 and SG3532 precision general-purpose regulators are substantially improved versions of the industry standard SG723. The SG1532 has a minimum required input voltage of 4.5 compared with the SG723's 9-volt specification. Lower voltages can be sustained across common 5volt regulators, reducing the dissipation.

The SG1532 has thermal shutdown and current-limit protection. The IC is protected even if an external pass transistor fails. A sense voltage of only 89 mV is needed to current-limit the SG1532 compared with 650 mV for the SG723, A series-current sense resistor is inserted in the output current path to trigger the current-limit protection circuit. At 650 mV and, for example, 10 amps, the sense resistor dissipates 0.65 × 10 or 6.5 watts-a lot of wasted energy. Eighty mV reduces the number to 0.08 × 10, or only 800 mW

The older SG723 design uses a Zener continued on page 101



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count down (pin 10 low) from its loaded count each time the clock (pin 15) receives a positive-going signal.

The carry output of IC6 turns off D10 (which has been grounding the bong DC amplifier, section D of IC7) and puts a high input on NAND gate C (pin 6) of IC4. At the count of 8 of IC2 counter A. the other input to pin 5 of gate C goes high, its output goes low and D8 stops conducting. On the ninth count of counter A (8 and I), diodes D7 and D8 are both reverse-biased and the bong generator is allowed to strike by enabling section D of IC7. On the very next count (0), diodes D7 and D8 are grounded. disabling the bong generator. Also, line 8 of counter goes low, so the gate C output goes high, clocking IC6. This subtracts one count from the preset total loaded in from IC5. Each time the pendulum swings into position V on count 8, the bong strikes once until the IC 6 count has gone down to 0. At this point, the carry line goes low, D10 conducts and the bong generator is disabled.

To achieve the bong sound, the bong DC amplifier (IC7-d) is enabled only when diodes D7, D8 and D10 are all turned off (with positive voltage on the cathode). When this happens, capacitor

C9 is allowed to charge through R9, a portion of R16 and D12 to a voltage level controlled by duration potentiomated R16. The charge on capacitor C9 controls the output of section D, which, in turn, controls the gain of section B through D14, R21 and R23. As the charge bleeds off capacitor C9, the section B output drops proportionally, giving a sustain effect and creating a bell-like sound through the speaker.

Tick-tock circuit

In regular operation, each time the pendulum swings to position Y on the count of 2 from counter A, capacitor C6 receives a positive charge. This charge remains on C6 during the count of 3, but on the count of 4 (the second count in position Z), C6 is suddenly grounded. This negative-going transition is inverted by IC3-f, and a short positive pulse is applied through D15, which turns on AC amplifier B of IC7, allowing a short toneburst to pass into the audio output section. The resulting sound resembles a tick. Similarly, on counts 6 and 7, the counter line 2 is high and capacitor C6 charges: on count 8 (the first count of pendulum position V) line 2 goes low, capacitor C6 discharges and causes another tick. There is actually no tock sound-just two ticks spaced 0.8 second and 1.2 seconds apart in the 2 seconds it

takes for the pendulum to swing back and forth.

The tick-tock is disabled when the bong is about to sound so that the bong sound is clean. The tens-of-minutes segment G transition on the hour triggers the set input of IC6 described earlier, and the carry output goes high. Since the 60-Hz count from the power line may result in the pendulum being anywhere in its swing at this instant, the carry-output high is inverted by section IC3-d and this negative-going transition is passed through C5 as a negative-going pulse to one input of NAND gate B of IC4. This results in a momentary high output of gate B, which resets counter A of IC2 to 0. Also, because inverter D now has a low output, diode D9 conducts, grounding the tick command from inverter F until IC6 completes the bong counting and the carry output goes to its normal low

Although the instructions are detailed and complete, this is not a kit for beginners, and it will take an experienced builder at least 10 hours to assemble it. But you really have something when you're finished—a large mantelpiece clock that displays the time digitally, has a swinging pendulum and tick-tock, and a bong that counts out the hours. Bullet Electronics, Box 1944E, Dallas, TX 75219. (continued next month)

OVERHEATING RESISTORS

I do get the weird onest This Sanyo SIGSIR came in with no picture and no sound. The voltage on collector Q831, the voltage-regularlor pass transistor, is +131; on the emitter it is only -77. I heckeds, and nothing seemed wrong. With the set on, resistors R882 and R883 became hot enough to mell solder. (There are shunt resistors across the regulator transistor). Error amplifier Q821 was bad. I replaced it, but now the circuit breaker cuts off? The rectifier diode is OK, etc. What's going on?—J. M., Houston, TX.

Everything is OK up to that regulator transistor. The shunt resistors overheat because collector Q931 obviously is not conducting at all. In normal operation, the transistor should carry most of the current. Disconnect the load on the +120-volt source. Remove the 1-amp fuse and connect a current meter across it. The normal current is 700 mA.

Check the error-amplifier circuit. It contains two transistors, and when that one went bad it could have damaged the bias resistors, etc. Also check the horizontal-output transistor to see if it has shorted.

AGC LOCKOUT

This Zenith 14N29Z showed an AGC lockout when the channels were changed. It stayed out for 3 to 5 seconds and then it came on. The AGC voltages read strangely. The AGC goes to +25 volts and then

slowly drops back. Checking the resistors in the AGC line gave no results. The AGC control showed hardly any range; the picture remained light. Checking the AGC keying pulse showed it was OK. The control grid voltage of the AGC tube showed far too much positive. Oh, oh! This voltage comes through a VDR.

When I freeze-sprayed the VDR the voltage jumped back to normal. I heated it, off we went again. Just for fun, I checked the resistance of the VDR—it waried (hot and cool) from 20 megohms to infinity. When I replaced the VDR, the set worked. This is Zenith part No. 63-5494, and you must be sure to get the right one! For a test, I replaced it with a 7.5-megohm resistor, and the set worked much better.

(This is a condensation of a page and a half of lab notes from my own bench!— Service Editor)

PROBLEMS GALORE

Here's an astonishing assortment of coincidences in a good old chassis:

In this Zenith 16Z25, cathode current in the 17DQ6 is 20 mA. The tube is good, the grid is very sensitive when touched with VTVM, and the 470,000-ohm grid resistor is open.

The raster shows a short, narrow, heavy shading from left to right. Is the filter open? Yes. This is a 10 μ F on B+ voltage. I replaced it. Result: a full blank raster but no sound.

The second IF voltages are all off,

Resistor R32 (120,000 ohms) to ground is open. The voltages are now OK. But there's no picture! I traced this to the radio-frequency AGC. Grounding the AGC on the tuner overloads the picture. Checking the RF amplifier shows the VI 20,000-ohm resistors are up to more than 500,000 ohms each. The set works now, but warms up very slowly. I finally find that a 3CB tube was used instead of a 4CB tube in the IF. End of story!

BREAKER TRIPS, RESISTOR BURNS When I turn on this Magnayor T-995-02

When I turn on this Magnavox T-985-02, I get audie and the high voltage starts to come up. Then the breaker trips out and the 2200-ohm resistor R20 on the video board begins to burn up. Lean't leave it on long enough to find out anything. Any ideas or tests?—J. S., Levitlown, PA.

We've got one clue: Resistor R20 is burning up. This resistor is in the supply to the ABL (Auto Bright Limiter) circuit, and it comes from the return lead from the high-voltage tripler. Obviously, this voltage is far too high; it should be about +24 volts. Here's a check: connect the voltmeter to terminal 11 on the vibra board and turn the set on. If this voltage reads way above 24, this will confirm your guess.

It sounds very much as if the highvoltage tripler breaks down when the high voltage reaches a given value. Disconnect the black lead from the flyback to the tripler and recheck. If everything else works try a new tripler.

STATE OF SOLID STATE

continued from page 99

diode reference, while the SG1532 has a lower noise band-gap reference.

Line regulation is 0.01%-per-volt maximum, and the output current capacity is



SILICON GENERAL'S SG1532 VOLTAGE REGU-

a minimum of 100 mA. The price is \$1.10 per unit in quantities of 100. Silicon General, Inc., 7382 Bolsa Avenue, Westminster, CA 92683.

Schottky rectifiers

Schottky rectifiers are ideal for power rectification because of their lower forward voltage and the resulting lower power dissipation. The 17-device MBR7520 family from Motorola has a greater trans-



SCHOTTKY RECTIFIERS FROM MOTOROLA

ient capacity than other rectifiers on the market. The diodes have a forward-current rating from 25 to 75 amp and have reverse voltage ratings up to 45 volts. Most devices in the series have dV/dt ratings of 100 volts-per-µs.

At a 100°C case temperature, 70-amp forward current and 45 volts, test units have been subjected to 8.3-ms, 1300-amp pulses once-per-minute, with no failures. The diodes recover from transients above the operating voltage specifications that drive them into temporary avalanche breakdown.

The rectifiers are mounted in DO-4 and DO-5 stud packages. Additional data is available from Motorola Semiconductor Products, Inc., Box 20912, Phoenix, AZ 85036.

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increase board density and/or duplicate a double-sided PC board. This is the only

system we have seen with this canability. Some of the possible Vector system variations are quite interesting, and among the available accessories are adapter pins for larger lead-wire sizes and a jumper wire kit The final breadboard system to be

examined is new in the United States. Having been used for some time in England, it is being imported and distributed by Saxton Products. This system is based upon modules called DeC's, and does not follow the usual .1 × .1-inch tienoint spacing. Each DeC module mea-



T-DeC WITH IC SOCKET mounted on adapter.

sures about 3 × 5 inches, and is constructed so that two or more DeC's can be locked together to form a single unit of any size.

There are three types of DeC's in this system: The S-DeC is for discrete circuits and has 70 tie points. The T-DeC, with 208 tie points, is used for discrete circuits with some IC's and requires IC sockets mounted on a special adapter sockets that have the correct pin spacing to fit the DeC boards. The Micro- or U-DeC is used for IC circuits, and comes in Type A (requiring IC sockets) and Type B (builtin IC sockets).

The Saxton DeC's are sturdy and well constructed. They do not permit as highdensity breadboarding as the other systems. However, their unusual tie-point pattern permits a somewhat simpler transition from schematic to breadboarded circuit. They also have another advantage, which we'll see when we get to the prototyping section in this article. Several accessories are also available.

Systems with indexed boards provide a facility that becomes more useful as the complexity of the circuit increases. For example, you can note on the schematic exactly where connections are made just by jotting in B3 or K48, etc. This can save time when you are modifying the circuit as you go along. It is also possible to code the index indicators on the schematic



S-DeC PROTOTYPING BOARD for discrete cir-

before you assemble the circuit. In addition to this advantage, the indexing also helps to eliminate wiring errors.

Finally, you should note especially the wire kits that are available. I had a little box of random length and color wires and thought this was as good as anything. More recently, however, I have been using one of the jumper-wire kits. These iumper wires come in various colors and lengths (in 0.1-inch multiples) and they can be used to connect one tie-point to another without wandering all over the board or arcing through the air.

Next month, we'll take a look at the various prototyping systems and wiring techniques. We will also discuss how to select the best method for building your own circuits

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is removable 2%" pro snags into wick refull amount as you need it. SD5 is the total system for maximum soldering/desoldering efficiency. Alone, the D5 tool is perfect for times

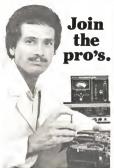
when you want to pocket the wick and leave the solder behind. And D5 is also refillable ... just snap out the Teflon* probe and plugin a D5 refill, available in two gauges - .10 inch and .06 inch. The Chemtronics

modular solder/desolder system can be purchased separately as half or one-pound spools of solder, D5 desoldering tool and D5 wick refill. Or as a complete SD5 unit with free D5 desoldering tool. Take advantage of this

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new products

More information on new products is available from manufacturers of items identified by a Free Information number. Free Information Card is inside back cover.

FUNCTION GENERATOR, model 301, is a versatile lab instrument for engineers, students and hobblysts. Unit provides three besic waveforms—sine, squere, end triangular waveforms over e 1-Hz to 100-kHz range. Operates with



either a single 12-volt supply or ±6-volt supplies. A squereweve output is eveileble at the sync output terminei for oscillioscope synchrorization or for driving logic circuits. Price: \$119, post-peld.—Printronix, 1361 Flatbush Ave., Brooklyn, NY 11210.

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WIRE TOOL, model 908-G, is five tools in one: wire stripper, bolt cutter, wire cutter; long-nose plier for pulling wire, loosening end tightening



small nuts; end wire crimper for solderiess connections. Tool messures 8½ inches long and has blue, piestic cushion-gripped handles. Price: \$8.90.—Channellock, Inc., Meadville, PA 16335. CIRCLE 110 ON FREE INFORMATION CARD

FREQUENCY RESPONSE RECORDER, model LFR-5600, meesures end piots frequency re-



sponse, wow & flutter, drift, voltage and temperature for e wide range of eudio equipment. Unit consists of two sections: an euflo sweep osciltori (with 20-48 and 40-48 attenuation for highsensitivity) tests), and e-pen recorder. Osciliatorcen also be used separately for direct-frequencyresponse readout on en osciliacopee. Client asterior of the control of the control of the control to Unit contains standard 1-kHz and 333-kHz signal frequencies for relet-for-eight or cessette to Unit contains standard 1-kHz and 333-kHz signal frequencies for relet-for-eight or cessette supplies for the control of the control of the external signals for response checks. The model LPF-8500, which comes in a stury built-in cerrying cess, costs \$2505.—Leader Instruments

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ceble end in-line connector, and stainless steel whip. Suggested reteil prices: trunk-lip mount, \$22.50; surfece mount, \$28.50; megnetic mount, \$28.50

ve., S.E., Cedar Rapids, IA 52402.
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TEMPERATURE METER, Digitemp 100, is a light-weight instrument with easy-to-read 0.33-in. LED display and edeptable to both hand-held operations and bench work (using optional adapter/oherger). With standard probes, unit measures a range of ~55°C (~57°F) to +150°C (~302°F) within ~0.5 degrees accuracy. OMS technology minimizes display drift to less than 0.1°C per 15-degree change. Meter operates on standard 5

volt battery; optional NiCad battery pack available. Other options include 3 standard probessurface probe, for measuring semiconductor and heat-sink temperatures, etc.; bolt-down probe for monitoring chassis and heavy machinery; and submersible probe for measuring liquids. Also available are adapter/charger and two sizes of



cable. Unit measures 4 × 27/4 × 15/4 in. weighs 8 oz. Prices: Digitemp 100. \$155 less probe: surface probe \$25: holt-down probe. \$27: submersible probe, \$25; adapter/charger, \$10; cables \$16 and \$22; and battery pack, \$10.— Mid-Continent Communications Co., 1103 Broadway, Oak Grove, MO 64075.

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55-CHANNEL MARINE VHF-FM TRANSCEIVER. Key/Com 55, is totally synthesized to provide keyboard entry of any VHF channel (domestic and foreign) without crystals. Unit can receive 34 additional police, fire and ambulance monitoring



channels and four weather stations. Contains loudspeaker, LED readout, dimmer switch, battery meter, Indicator light. Key/Com 55 measures 3 × 8 × 9 inches and costs \$659.95.—SBE, Inc., 220 Airport Blvd., Watsonville, CA 95076

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HARDWARE FLOATING POINT BOARD, model FPB-B, is compatible with the Z-80 microprocessor and is specially designed for applications needing fast floating decimal calculations. Board is compatible with SBC-80 bus. The model FPB-B uses BCD enumeration to perform add, subtract,



multiply and divide with selectable precision up to 14 digits. Included is a paper tape version of extended BASIC. Prices: kit. \$299; assembled. \$399.—North Star Computers, Inc., 2465 Fourth St., Berkeley, CA 94710

CIRCLE 118 ON FREE INFORMATION CARD

MULTI-TESTER, model SP-170, comes in a rugged plastic case with convenient carrying handle. Multimeter ranges are: 2.5-1000 VAC; 0.25-1000 VDC; 0.05-500 mA DC; 10 amps DC; 2K-20 megohms and -20, +56 dB. Sensitivity is 20,000 ohms/VDC and 5000 ohms/VAC. Contains 21nosition selector switch, two-color scale, safety front nanel polarity selector switch. Unit is fuse protected on all ranges except 10 amps DC. The model SP-170 is battery-powered-uses one Ccell and one 9-volt transistor battery. Comes with



test leads, fuses, batteries, instructions. Weight under 2 lbs. Prices: model SP-170, \$73.50; optional carrying case. model C-11. \$14.75. a.w. Sperry Instruments, Inc., 245 Marcus Blvd... Hauppauge, NY 11787

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DUAL-TRACE OSCILLOSCOPE, model LBO-515, is a dual-channel, 25-MHz instrument with a built-in variable delayed sweep of from 1 µs to 5 sec. Offers a 5 mV-per-division vertical sensitivity: rectangular CRT with internal graticule; selectable sync: auto, normal, single-trace and



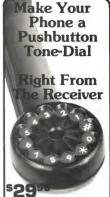
reset modes with 20 Hz-10 kHz rejection. Features include beam rotator, Channel 1 & Channel 2 trigger with polarity inversion for Channel 2, front-panel astigmatism control, ×10 magnification and 14-ns risetime. Finger-contoured handle doubles as locking bale. Priced at \$1395, the model LBO-515 comes complete with probes and accessories.-Leader Instruments Corp., 151 Dupont St., Plainview, NY 11803,

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CB TRANSCEIVERS, Old Hickory, Adams (shown) and Madison, are 40-channel units all



providing 4-watt power output and 100% modula tion capability plus standard controls. Budgetcontinued on page 110



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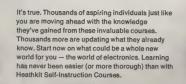
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Essentially, Course 1 covers current, voltage, resistance, magnetism, Ohm's Law, electrical measurements, DC circuits, inductance and capacitance. In short, a complete foundation in basic electronics. Included are texts, records, and 56 electronic components for 20 different experiments. Also available is the ET-3100 Experimenter/Trainer that helps you perform projects and experiments quicker. The average completion time for Course 1 is 20 hours.

If you choose to take the optional final exam and score a grade of 70% or better, you will receive a Certificate of Completion and 2.0 Continuing Education Units (CEUS). CEUs are a nationally-recognized way of acknowledging participation in non-credit adult education. Course FF-3101

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NEW PRODUCTS

continued from page 105

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MICROCOMPUTER SYSTEM CATALOG. Byte. Shopper, features all kinds of microcomputer schemes, from the simplest home setup to large timesharing, multi-user systems. Each product described includes not only specifications but a complete discussion of how it works and its application. More than 50 manufacturers are represented, and almost all products are S-100 buscompetible. Cetelog is eveilable for \$2.50,-Byte Shopper, Byte Shop of Arizone, Box 28106. Tempe, AZ 85282.

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INSTRUCTIONAL BOOKLET, A Brief Guide to Microphones, 15 pages, uses a step-by-step epproach to a basic understanding of different microphone types end features. Eight besic microphone terms are described, and an edditional section deals with mike accessories.-Audio-Technica U.S., Inc., 33 Shiawassee Ave., Fairlawn, OH 44313.

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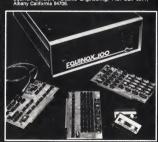
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BUGBOOKS V AND VI, by Peter R. Rony, David G. Larsen and Jonathan A. Titua. E&L Instruments, Inc., 61 First St., Derby, CT 06416. Bugbook V, 493 pp.; Bugbook VI, 490 pp. 6× 9 in. Softcover \$9.50 each.

These two volumes combine a course in introductory digital electronics with programming and interfacing an 8080A-based microcomputer. Designed for study and guidance in performing 'hands-on' experiments with a low-cost microcomputer, breadboards and available components.

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signar gates airu nutwinderus. Bugbook VI contains detailed instructions and lab experiments with instruction set, three-state busing techniques, and accumulator and memory-mapped I/O techniques. This volume also covers advanced I/O concepts and interrupt servicing. Complete appendices for both volumes are contained in the back of Bugbook VI.

GROUNDING AND SHIELDING TECHNIQUES IN INSTRUMENTATION, Second Edition, by Raiph, Morriaon, Wiley-Interscience, Div. of John Wiley & Sone, 605 Third Ave., New York, NY 10016. 146 pp. 6 × 9 in. Hardcover \$15.50.

This is a revised and updated version of an earlier popular book for engineers, technicians, designers, and anyone concerned with electronic equipment. Notice has been taxen of more defectually, and schematics have been revised for cuts, and schematics have been revised for entering the experiment of the properties of the experiment o

LOGIC DESIGNER'S MANUAL, by John D. Lenk. Reaton Publishing Co., Div. of Prentice-Hall Co., Reaton, VA 22090. 504 pp. 6 × 9 in. Hardcover \$18.95. This book introduces the reader to commer-

claims 1000 milliouses are research or communications and the last of respective applications. The text and flustrations show how these IC's can be interconnected to form logic systems. Chapter 1 is an introduction to logic design; Chapter 2 describes how decoders, counters, etc., work; the remaining chapters cover such subjects as A/D and D/A converters, arthmetic units, memories, interface and other logic circuits.

SECURITY ELECTRONICS, Second Edition, by John Cunningham. Howard W. Sams & Co., Inc., 4300 W. 62nd St., Indianapolia, IN 46268. 192 pp. 51/4 X 87/4 in. Softcover \$5.95.

This book takes a look at how various electronic security devices and systems work, and suggests what type of system is best for specific applications.

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AUDIO OSCILLATORS

continued from page 73

Figure 4 shows another popular circuit-the L-C (inductance-capacitance) combination. Figure 4-a is the Hartley oscillator, which uses a tapped inductor and Fig. 4-b is the Colpitts oscillator, with a split capacitor. The natural frequency of either of these oscillators depends on the square root of L X C. Therefore, for a 10:1 tuning range, the value of C (or L) must vary by 100:1. This is one of the major disadvantages of the L-C oscillator: Another major disadvantage lies in the size of the inductance and capacitance required to reach low frequencies. The advantage of the L-C oscillator lies in the ease with which a high-Q (high-selectivity) tuned circuit, which results in extremely pure sinewaves can be obtained

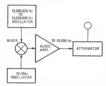


FIG. 5-THE BEAT-FREQUENCY TYPE. The audio signal is the difference-or beat-between two separate radio frequencies.

Today an L-C circuit is not often used. However, it was commonly used in heterodyning or beat-frequency oscillators, as shown in Fig. 5. This arrangement has an extremely wide frequency range. For instance, the oscillator in Fig. 5 can cover a 20-Hz to 20-kHz range, while the L-C 10-MHz oscillator frequency changes by only 2%. (Such oscillators often have frequency stability problems.)

Two forms of frequency selection are common. One is switch-selectable decade ranges, with a continuously variable frequency adjustment within the selected decade. Such oscillators are continuously tunable and usually have a ganged variable capacitor that is adjusted to produce changes within each decade. Ranges are changed by changing sets of resistors. The L-C oscillator ranges can be changed by adjusting taps on the inductor or switching in new inductors.

Selection of discrete frequencies by switches is the other frequency selection method. Although not as common as continuous tuning, it has many operational advantages. When switched frequency selection is used, ranges are changed by selecting sets of fixed capacitors whose capacitance increases in decade steps.

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Within a particular decade, frequency is adjusted by selecting appropriate resistors. In other words, the switched tuning technique usually inverts the role of capacitance and resistance as compared with continuous tuning.

Designing an oscillator suitable for generating fundamental audio oscillator signals involves many techniques for reducing distortion and noise to the lowest possible levels. The amplifier in the basic oscillator circuit must have extremely high gain over the entire frequency range used. The higher the gain, the greater the feedback and the lower the distortion. This amplifier must not introduce any appreciable phase shift over the oscillator's entire frequency range. Amplifier noise and hum must be reduced to the lowest possible levels. Frequency stability with component aging and temperature variations must be carefully considered. Any effect that would tend to modulate the basic oscillator signal in either amplitude or frequency must be removed, as all these effects contribute to total distortion.

Output amplifier

The output amplifier has three purposes. First, it supplies some gain to increase the oscillator output amplitude to the maximum level required. Second, the amplifier serves as a buffer, isolating the oscillator from load changes at the output. Third, it serves to reduce the output impedance of the oscillator stage to the required impedance (usually either 50 or 600 ohms). Most amplifiers used for this type of work consist of one or more Class A amplifier stages. The am-

output. A series resistor at the amplifier output yields the desired impedance. Although this limits the maximum power transfer capabilities of the amplifier, it does insure a reflectionless signal

source. Designing the output amplifier for the audio oscillator requires great care to avoid introducing hum, noise or amplitude modulation. Low noise techniques and careful shielding are routinely applied to such amplifiers. Other more advanced techniques, such as special isolating transformers, are not uncommon. Additional leveling techniques can be applied at the output amplifier, although they are more commonly applied at the oscillator.

Output attenuator

Output attenuators may vary in complexity from the very simple to the exotic. Figure 6 shows an extremely simple attenuator. The output impedance of the audio oscillator varies with the setting of the 400-ohm variable attenuator. The output impedance of this circuit may drop to nearly zero at the minimum setting.



monly used on low-priced audio oscillators.

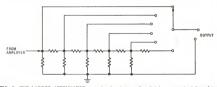


FIG. 7—THE LADDER ATTENUATOR operates in steps and maintains a constant impedance throughout its range.

plifier in common use consists of a number of stages connected to form a highgain, wideband, low-noise circuit.

Normally, the gain of the output amplifier must be in the range of one to five. Large amounts of negative feedback are introduced to reduce the gain to this required range, which tends to improve amplifier frequency response, phase and distortion characteristics. Frequently, the amplifier output impedance, which has been reduced to an extremely low value by the large amount of feedback, is significantly lower than required at the

Attenuators like the one shown in Fig. 7 are common in more sophisticated oscillators. The continuous variable attenuation is inserted before the amplifier stages. Therefore, the output impedance tose not vary as the continuously variable attenuator is adjusted. The step attenuator is of the constant-impedance type, with either 10-dB or 20-dB steps, and maintains either a 600-dnm or 50-ohm output impedance regardless of attenuator setting.

The design of the output attenuator turn page

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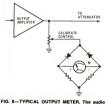
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must insure identical performance at high and low frequencies. This becomes especially important if squarewayes are included; they contain components of much higher frequency than the sinusoidal waveforms of the same frequency. Equal attenuation of the high-frequency and low-frequency components is necessary to reproduce the squarewave faith-

Metering circuits

Many audio oscillators display the exact output signal amplitude on a meter. Normally, the metering circuit monitors the signal applied to the fixed attenuator and the attenuation supplied by the fixed (step) attenuator is presumed to be constant and accurate. Metering circuits require a rectifier that is flat over the entire frequency range of the oscillator. The rectifier-circuit output drives the meter: a typical circuit is shown in Fig.



frequency is rectified and measured.

Squaring circuits

The Schmitt trigger is the circuit most commonly used to generate a squarewave from the internal sinewave of the audio oscillator. The Schmitt trigger circuits are usually designed to avoid fast risetimes to keep noise from entering the sinewave output. The input to the squaring circuit must be buffered so it does not affect the sinewave characteristics by loading. The squarewave output of the Schmitt trigger is passed through a simple amplifier, reducing the output impedance to drive an attenuator.

Frequency control Some audio oscillators offer auxiliary circuitry giving a few percent frequency variation. This feature permits locking to an external standard for more precise frequency control. Depending upon the basic oscillator circuit chosen, the external frequency control circuitry consists of an electronically variable capacitor to shunt the oscillator canacitance, or electronically variable resistors to shunt the oscillator resistance elements. Light-dependent resistors or Varicaps are used.

Specifications

The specifications of an electronic instrument are usually provided briefly in advertising, and in more detail in the operator's manual. Audio oscillator specifications. like those of most other instruments, vary from a simple listing covering less than a page to detailed listings covering a number of pages (generally found on more expensive units). Frequently such specifications vary from manufacturer to manufacturer and at times even among instruments sold by the same manufacturer. It is therefore important that the user be able to organize the specifications in one common format to compare audio oscillators so he can decide on which one to buy

Frequency range

The frequency range specification indicates the lowest frequency generated as well as the highest frequency generated. This specification also indicates the number of ranges over which the oscillator must be tuned to cover its complete frequency range.

A note of caution: It is common to advertise only those performance specifications that lie within the classic audio frequency range (20 Hz to 20 kHz). Low-frequency limits for audio oscillators may run from a fraction of a hertz for the most sophisticated oscillators to 10 Hz for the lower-cost units. In higherpriced models, upper frequency limits of 1 MHz to 2 MHz are common. Lowercost units may extend to an upper limit of only 100 kHz. All extend beyond the classic audio spectrum, and one cannot assume that a specification holds over this entire range. Read all the specifications to determine the canabilities of the audio oscillator at any particular freauency.

Frequency setting accuracy

Frequency accuracy, given as a percentage of the operating frequency, varies from a precise ±0.5% on switch-selected incremental oscillators to an error of ±5% on the less expensive units. For most work, a ±5% accuracy is entirely acceptable. Accuracy specifications for oscillators with switched incremental frequency tuning are given with any vernier frequency control in a fixed calibrate position. On oscillators with an excentionally wide frequency range, a reduction in accuracy should be expected at the extreme ends of the range.

Audio oscillators are not intended to be used as frequency standards, and a high accuracy level is not generally necessary. Applications such as measuring the bandpass characteristics of extremely sharp filters, or measurements in such cases where legislation requires compliance to a frequency tolerance, may require an external frequency meter for ultimate accu-

to be continued

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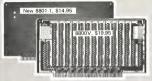
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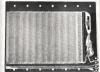
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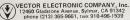


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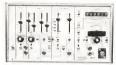
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SELECTING A DMM

continued from page 66

best. The reason is that when high voltage is applied to a metal-film resistor, it typically fails by opening up until the metal film melts, then it shorts and finally opens. This, of course, defeats the desired protection. A carbon-composition resistor under the same conditions will typically open without the interim short.

"Another way to implement ohms protection is to use an active protection device. This is used in our new ohms circuit." (See Fig. 6.)



FIG. 6-ACTIVE PROTECTION CIRCUIT used in the ohms circuit of the digital multimeter.

"In normal operation, transistor Q1 is saturated and diode D1 is on. Consider the two opposite polarity cases (Fig. 7):

"The input to the op-amp is limited to -0.7 volts, causing the output to go positive which turns off O1 (Fig. 7-a). Transistor O1 is a 450-volt switching transistor. so nearly all the 163 volts appear at its collector. Since O1 is off, virtually no collector current flows, and Q1 does not dissipate a large amount of power.





FIG. 7-ACTIVE CIRCUIT PREVENTS external voltage from damaging the DMM ohms circuit. Diode D1 and Q1 are the basic components.

"In Case 2 (Fig. 7-b), the op-amp output is negative, which forces transistor Q1 on. The input is limited to +0.7 volts, and diode D1 is off.

"So now we have an ohms converter that is protected, even if a 220-volt line is connected to it. I think you'll agree that we make our product rugged."

George is visibly impressed, "I had no idea you people spent so much time with reliability and customer satisfaction. I wish I had known before I bought my first DMM. Of course, I probably would still have purchased your product.

George now realizes the forethought and extra testing effort that went into the design of his DMM. He will gladly pay more for a DMM whose usability he can verify from careful scrutiny of the data sheet. He wanted a "quality" DMM, and the service reputation of the manufacturer has already paid for itself. With renewed confidence in his DMM, he steps out of the Whoopee-tronics service center into the bright sunshine and hurries off to reenlist in the summer bowling league.





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frequency for all 40 CB channels. In our tests, the most deviation was about 20 Hz, which is far tighter than the average CB radio. The PLL uses an IC programmable divider to change CB channels. You just punch the two numbers in on the 12-button keyboard, and then press one of the two ENTER pushbuttons. The RF output locks tightly onto the reference, and a bright LED pilot labeled PHASE-LOCK lights! The channel number appears instantly on the two-digit LED readout. An IC memory remembers the correct divisor for the channel

If you press the wrong pushbuttons, and the

LED readout gives you a number that is not one of the 40 channels (such as Channel 46 or Channel 95), this number shows up on the readout, but the PHASE-LOCK light stays out You must press a 0 pushbutton for the first nine channels-i.e., "01," "06," etc. Hickok states that the PLL can be programmed for any extra channels in the 27-MHz hand that may be added later.

The RF signal output is monitored by a panel meter, which reads directly in microvolts. The meter can be set in six steps, from X1 to X100K, and has a continuously variable level control. You can obtain any signal strength needed, from 100-mV RMS down to microvolt levels. The attenuator is also calibrated in dBm, and there is a dBM scale on the meter. (Example: 0 dBm= 1 mV. or 1000 μV.) This is especially useful for measuring adjacent sideband rejection, squelch setting, etc., that must be a certain dB below a reference level.

You can generate both AM and SSB signals. On AM, the RF signal can be unmodulated (or modulated) with an accurate 1.0-kHz signal. Pressing a button adjusts the modulation percentage from 0% to 100%; you can then read this on the meter.

For SSB tests, set the model 266 to the CB channel desired without modulation. Set the CB rig to the same channel and to either upper sideband (USB) or lower (LSB). Now just press the USB or LSB pushbuttons on the front panel. The PLL moves exactly 1 kHz in either direction. The resulting RF signal is the same as a sideband signal with 1000-Hz modulation. The modulation percentage is also adjustable.

continued on page 122



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continued from page 34

use the other hand to hold the soldering iron and feed solder with the fourth hand! With the model KL-3000, you can hold the board and part with one hand, and use the other hand to solder it.

The soldering pistol uses small-gauge solder, 031- and 050-inch in diameter. In the standard model KJ. 3000, the feed-reel is mounted on the top of the gip at the back, almost flush with the grip. Enough of the small solder can fit on this reel for quite a lot of joints. If a larger capacity is needed for production-line work, etc., you can mount a larger solder reel that holds three times as much as the standard reel. For making many joints without stopping, you can even obtain a bench-mounted reel that holds 2.2 lbs. of solder, or one kilogram!

The model KL 3000 comes in 20-, 30-, 40and 60-watt sizes. The heating elements are interchangeable and can all be used in the same handle. The solder feed must match the size of the solder used, but this only requires changing the feed tube, which is not hard to do.

A great many soldering tips are available: 10 different 4-mn tips for the three lower heats, and 16 tips in the 6-mm size for the 60-watt unit. The tips are all specially coated so that you never file them. You just wipe them off with a wet sponge, and you're ready to go again. A bench stand is available that holds the pistol in the recommended upright position. And you can use any stocks solder-gun holder.

The four stock pistol sizes are 115-volt ACpowered. A 24-volt unit, powered by a stepdown transformer, is rated at 40 watts. By changing taps, this unit can be used at 20 or 30 watts. An electronic temperature-controlled unit is also available for precision control of tip temperature.

We found a small junked PC board, put some parts in it and tred the pisto out. After only a little practice, we could make really smooth professional-looking joints with case. A thumbserew under the barrel can be used to adjust the amount of solder that is fed out when you press the trigger. The trigger also has click-stops that you can use. One squeeze delivers enough solder to make any averagesized joint, with one or two leads.

You can obtain the solder from Kager or use any stock solder. The sizes are standard. For all IC work or for very closely spaced

joints, this pistol is a very useful tool. R-E

Hickok Model 266 CB Signal Generator

THE HICKOK ELECTRICAL INSTRUMENT COMpany, 10514 Dupont Avenue, Cleveland, OH 44108, have been manufacturing RF signal generators for a long time. (Other things too, of course!) There's a model 188 generator on my bench that's been there since 1935! It works, too.

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MAKE YOUR OWN CUSTOM HARDWARE

continued from page 71

IC lead pin, solder the wire to the T-44 pins, put in a strain relief, and again mark pin No. 1 on this socket connector. The Glomper clip now can fit itself to an IC socket, yet still has testing points as handy as the original unmodified Glomper test

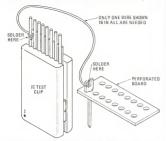


FIG. 16-IC TEST CLIP can be modified with a piece of cable and a home brew jig to plug directly into an IC socket.

clip (see Fig. 16). The wire cable should be kept to under 36 inches, and 24 inches seems to work nicely. This same test clip prewired would cost a small fortune at the electronic shop, and for only pennies you have made the same unit.

Star No. seven

Just a helpful tip to those who use a great deal of solder wick to remove IC's and other components from boards. The cost of this wick is quite expensive. So, if you have some old zip cord, why not save some hard cash? Simply strip the cord to the braided wire, smear on some flux and use this in place of the solder wick

Throughout this article I have given the names and addresses of makers of the special hardware stars I have introduced you too. Why not write them for their catalogs and try some of the ideas presented in the article next time you need a special situation device. Don't be afraid to try your hand at some modification of your own making, and let's hear from you through Radio Electronics; us home brewers have to stick together just to keen out of hot water.

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EQUIPMENT REPORTS continued from page 120

This test is a fast check for upper or lower sideband rejection, RF sensitivity and centering of any fine-tuning or clarifier controls on the CB transceiver.

A noise generator circuit is also included that produces a standard pulse-train noise. with a width of 1.0 us and a 100-PPS repetition rate. This noise is superimposed on the RF output signal. It can be used to check the receiver's noise blanking, noise limiter, etc., circuits on either AM or SSB.

For IF alignment and many other tests, the model 266 has a crystal-controlled 455-kHz signal that is 30% modulated and variable. For dual-conversion receivers, a crystal on the first IF frequency can be plugged into a crystal socket, and used to check this stage.

The IF test is also useful for checking a CB rig with a frequency synthesizer. Feed an unmodulated RF signal into the input of the CB rig and then press the 455-kHz IF signal output pushbutton. Couple the 455-kHz 1F signal into the second IF stage. If the CB isn't exactly on-frequency, you'll hear an audible beat note in the speaker. Just tune the synthesizer for zero beat, and the job is done. A mistuned synthesizer can cause low sensitivity, etc. You can use the crystal function to check crystals for activity and frequency. Just plug the crystal into the model 266, select the crystal via the front-panel pushbutton and read the frequency on a counter connected to the IF output of the model 266. Crystals in the 1- to 20-MHz range can be checked out. Third

overtone crystals, used in many CB's, oscillate on the fundamental frequency, at one-third the RF frequency

The model 266 has an RF signal output of up to 100.000 µV, and an IF output signal of 150 mV. This output is sufficient to operate a frequency counter directly. The step attenuator on the RF signal output uses precision resistors and careful shielding, and the output signal can be adjusted down to a level of 1.0 uV or a bit less. If fractional-microvolt signals are needed for an especially sensitive CB, you can construct a simple 20-dB attenuator that divides the RF output signal down by the necessary amount. The manual contains full construction details for this Amplitude-modulated CB's, as well as

SSB's, can be easily checked for adjacentchannel rejection. Measure the sensitivity of the CB rig and then switch the PLL to the next channel in either direction. Increasing the RF output signal level until the output meter shows the same reading provides the adjacentchannel rejection ratio in dB instantly

SSB tests are equally simple. For adjacentsideband rejection, just measure the sensitivity on the USB, set the meter, then switch the model 266 to the LSB setting. Bring the signal level up until the meter shows the same reading, and read it off the RF meter in dBm.

Even the receiver's audio stages can be checked for maximum power output as well as for frequency response. For power tests, just read the RMS voltage across the speaker voice coil or a dummy load with a high signal input. Two charts in the instruction manual show the signal voltage for any power level-from 0.1

continued on page 148



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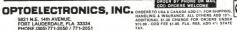
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Selectable Input Attenuation—X1, X10, X100
Input Connectors Type—BNC

Approximate Size—3"h x 7½"w x 6½"d Approximate Weight —2½ pounds

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· Converts a low cost tape

· Works up to 1200 baud

mic, in of recorder

to input on board

· No coils

recorder to a digital recorder

· Digital in and out are TTL-serial

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· Earphone of recorder connects

· Requires +5 volts, low power

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Е	MAN-3 BUBBLE READOUT, 19" red, com ceth. (#483338) MAN-4 READOUT, bubble, red, com anoda (#4R1503)	2 fer 1.00	12 for 1.01 4 for 1.01 4 for 1.20 2 far 1.56
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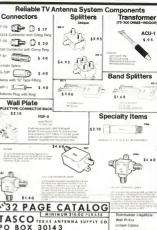
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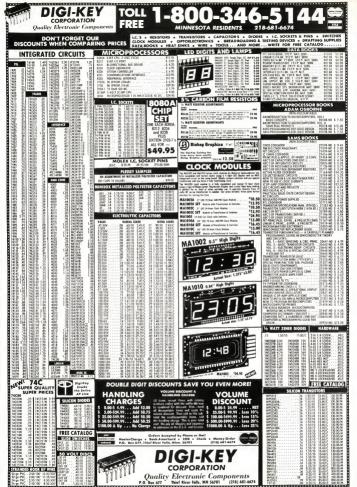
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watt to 10 watts. You can even read the audio frequency response of the receiver. An AF signal generator can be connected to the external modulation jack on the front panel. Set up a reference level at 1000 Hz, then vary the frequency above and below this level.

You can use the variable RF signal output to check squelch threshold, control action, the signal needed to break squelch, etc. The same setup also checks out the automatic gain control on any CB receiver. Just inject the AM signal at 30% modulation into the input, then set the model 266 for a high RF signal, at 50,000 µV. Connect an output meter across

the external speaker jack, and note the reading. Now reduce the RF output signal slowly to about $1.0\,\mathrm{gV}$. The audio output signal should drop slowly and smoothly without dips or peaks. The audio output at the lowest signal level should be no more than 30 dBm below the reference level set up with the high RF signal. This procedure will also check and calibrate the 3-meter on the CB, if one is used; this should read maximum at the high signal output and then drop to zero at the lowest RF signal.

The model 266 CB signal generator is a versatile piece of test equipment that is surprisingly easy to set up and use. The RF step attenuator is a 6-position switch; the RF modulation and IF levels are variable controls, and everything else is done with pushbutch.

The instruction manual contains full setup data (including all the control positions for both generator and CB) for every kind of test imaginable. The manual is actually like a good CB troubleshooting handbook, Full checking and recalibration instructions are given. There's even a complete list of CB channel frequencies, which is nice because I'm sure not going to ever remember c'en!

— R-E-

Philips/MCA, Inc. announce two-hour videodisc format

A new two-hour playing format for optical videodiscs was announced recently by Philips and MCA, Inc., that will enable the viewer to enjoy full-length feature films and programs of up to hours in length on a single double-sided disc.

The optical videodisc player will not only accomodate the two hour format using variable angle velocity, but also play programs recorded at the present 1800 RPM format. Magnavox will market the player and the videodisc will be handled by MCA Disco-Vision.

lon implantation improves FET's, optical couplers and solar cells

Several ion-implantation methods are presently being developed that are expected to improve the performance of microwave FET's, create new optoelectronic devices for use in telephone couplers and fiber-optic communications, and increase the efficiency of solar cells.

Hewiett-Packard has built an Ion-implanted FET that, as a result of its planar construction, promises greater reliability than conventional crystaline devices. The company sees the potential application of these FET's in GAsa IC's. With a 5-d8 gain, Iff researchers have been able to obtain Iff researchers have been able to obtain GHz and a power-added efficiency of 34%. Avantek, Inc., has also been working with low-noise microwave FET's; sillicon implanted into a GaAs semi-insulating substrate results in a shallow but steep profile.

On the optoelectronic front, Bell Labs has developed two semiconductors—one, a bilateral phototransistor to be used as an optical coupler in telephone switching, and an optically switched LED to interface between digital logic circuits and glass fibers. Bell researchers believe this LED has application in a tay and-repeater circuit.

With the possibility of having an effect on the national energy crist, the efficiency of solar cells has been improved by a special chemical process developed by the Jet Propulsion Lab of the California Institute of Technology at Pasadena. The oxide surface layer of the gallium-arsenide MOS cell is formed by physical deposition, and pulsed-laser evaporation is used to improve the antireflecting coating of the solar cell surface. This has pushed the efficiency of the GaAs MOS solar cell to 176%.

of the GARS MIOS solar cell to 17%.

Texas Instruments has also created a tandem-junction thin-film solar cell with collecting junctions on both the dark and illuminated sides of the cell. So far, experimental solar cells have yielded an open-circuit voltage of 600 mV, a short-circuit current of 50 mA per-square-centimeter and an 18% efficiency at 25°C.



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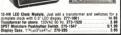
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HOPFLESS PROBLEM

This Zenith D3720L is a hopeless problem! There's no high voltage and the horizontal output tube isn't conducting. The drive waveform checked good as did the DC supply voltage. deflection voke, etc. I replaced the flyback-no change. I note that the DC voltage on pins 3 to 11 of the 20LF6 drops from +300 to only +60-A. H., New York, NY.

Nothing is hopeless if you attack the problem systematically. There are 17 different things you must eliminate in this kind of problem, and there may be more. You've already eliminated quite a few. Now, the one significant reaction is the high-voltage drop in the 20LF6 screen grid voltage when the set warms up. I've seen this before.

There are two possible causes for the voltage drop. One is that the top cap on the 20LF6 may not be making contact, so there is actually no plate voltage. The screen does have voltage, so it tries to act as the plate and the resulting high current causes the voltage to drop. Check the continuity between the 20LF6 plate can lead and the damper cathode; this should read only a very few ohms. Also check the solder joint between the lead and

The other cause is even rarer, but it has shown up lately. Try another 20LF6 tube. We've run into this before, and there is some weird defect in the tube itself, showing up even in new tubes. Open the 20LF6 cathode and read the current to find out whether the tube is taking excessive current or not enough.

Here's another rare cause for your problem. Place a DC voltmeter on the damper cathode and turn the set on. You should read the full B+265 volts here as soon as the damper tube warms up. If you do not, try a new damper tube; sometimes the cathode ribbon in some of these tubes opens up.

HORIZONTAL RADIATION

A reader recently wrote about some incorrect answers to Reader Ouestions in the November 1977 issue. His letter contained one remark that I'd like to correct. Referring to a question dealing with horizontal radiation from one TV set into another, he wrote "your answer is more theoretical than practical," etc. And claimed this radiation was due to co-channel interference!

Not so. This answer was the result of actual personal observations of real sets, as well as many letters from readers with the same problem. For instance, in the first case I ever saw years ago, an old Dumont 301 in a two-set home would tear up the picture on a portable in the next room! The cause: one of the 5U4 rectifiers was very gassy. Whenever possible, which is most of the time, the published answers in Reader Questions have been verified by reader feedback.

COLOR PROBLEM

I've got a lulu of a problem here. This set was vandalized by an angry husband who had to turn it over to his wife as a part of the settlement! I found and fixed all the missing and broken parts. and got it working. The set came back with a focus problem; I fixed that. Now I've got a fine sharp black and white picture, but no color at all! With the set working, all I can get in the color circuits is a big flattened horizontal pulse. If I open the cathode of the horizontal-output tube, the color waveforms come back, all the way to the picture tube grids! What the Sam Hill is this?-R. M., Kensington, MD.

From the symptoms you describe, this color problem is being caused by the presence of the horizontal blanking pulse! When you kill the horizontal output, you kill these pulses. Since the color-signal circuits are obviously working, something in the blanking circuitry is causing the color to be blanked out.



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14	Aldelco	
108	American Technology	
16	A P Products	
10	A T V Research 123	
17	Avanti Research & Development Cov 1V	
51	Bahylon Electronics	
106	B & K Precision Dynascan	
	C F R Associates	
58	Chancy Electronics	
92	Chemtronics	
	C 1 E - Cleveland Institute of Electronics	
	18-21	
	Command Productions 124	
95	Communications Electronics 122	
94	Computer Depot	
	Contemporary Marketing 105	
86	Continental Specialties	
5	The Cooper Group Electronics Division 2	
	C R E I - Div of McGraw Hill Continuing Education	
	Dage Scientific Instruments 148	
69	Davis Electronics	
40	Delta Electronics	
75	Delta Graph Electronics	
	Devtronix Organ Products 128	
64	Digi-Key	
96	DRC Electronics	
,,,	DR1 Industries	
87	EICO113	
83	E & L Instruments 120	
22 .	Electronic Discount Sales 150	
73	Electronic Control Systems	
56	Electronic Systems	
	E M C - Electronic Measurements 122	
19	Enterprise Development	
70	Etco Electronics	
	Fair Radio Sales	
	Fidelity Sound	
57,80	Fluke	
88	Fordham Radio Supply	
	Forest Belt	
62.91	Formula International 135,142	
7	Fuji-Svea146	
38	Godbout Electronics	
82	GTE Sylvania-Consumer Renewal 32	
21	Grantham College of Engineering 118	
	Golden Enterprises123	
100	Heath28-31,106-109,115	
31	Hickok Electrical Instruments	
71	Hohhi House	
11	Indiana Home Study 114	
	Information Unlimited	
23	Integrated Circuits Unlimited	
43		
34,33	International Electronics 124,125	
52,53,54	James Electronics	

29	J S & A National Sales Group
	Krystal Kits 14
	Lah Science
	Lakeside Industries 14 Leader 8
74	L M N Electronics
18	Mallory
15	McKay Dymek 11
2	Meshna
103	Mountain West Alarm Supply
103	
15,9	National Camera
17	New Tone Electronics
14	Netronics
5	O.K. Machine & Tool
7	Olson
9,60	Optoelectronics
	Page Digital 14
5	PAIA 11 Panavise 11
17	Devecitic Engineering 11
10	Philips Test & Measuring Division 1
18	Platt Luggage 11
10	Philips Test & Measuring Division 1 Platt Luggage 11 Plus Electronics 14 Poly Paks 13
07	Pomona 10
7,28	Priority 1 Electronics
6	P T S Electronics 8
.5	Quest
5	Radio Hut12
_	Radio Shack
16	Ramsey Electronics
19 15	RCA
0	Sahtronics
2	Schober Organ 11
6	J.B. Saunders 14 Schober Organ 11 SD Computer Products 12
	Sencore 9 Shure Brothers 9
16	Simpson Flectric
1	Solid State Sales
4	Solid State Sales
l6 19	Southwest Technical Products
7	Spacekom 2 Starshine 3
	Superscope Cover Surplus Center 12
	Surplus Center
3	Tah Books
8	Tarbell Electronics
04	Tasco 14 Texas Tuner Service 11 Trumbull 12 Tri-Star 12
,	Trumbull 12
7	Tri-Star 12
0	Ungar - Div. of Eldon Industries
9	Vector 11
3	V1Z Mfg 3
	Wahl Clipper9
12	Wersi Electronics 11
4	Western Data Systems
8	West Side Electronics



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